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Journal

of the

American Welding Society

May, 1928

Published Monthly

by the

AMERICAN WELDING SOCIETY

33 West Thirty-ninth Street

New York

American Welding Society

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JOURNAL

of the

AMERICAN WELDING SOCIETY

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AMERICAN WELDING SOCIETY
ESTABLISHED 1919
JOURNAL

Volume 7 MAY, 1928 Number 5

Officers and Directors Elected at Annual Meeting—A. W. S. April 26, 1928

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Officers Appointed—Board of Directors' Meeting April 27, 1928

Treasurer—C. A. McCune, American Chain Co., Inc., Bridgeport, Conn.
Secretary—M. M. Kelly, 33 West 39th Street, New York, N. Y.

Annual Meeting

The last Annual Meeting of the Society held on April 25-27 was a remarkable demonstration of the growth and development of the American Welding Society. Keen interest and enthusiasm was displayed as indicated by discussion of papers at the technical sessions. There was a registered attendance of 190 people.

The discussion at the three technical sessions was spirited and to the point.

The President's Annual Report is given elsewhere in this issue, as are also a number of technical papers and discussions not previously published. The remainder of the oral discussion will be printed in the next issue of the JOURNAL.

At the Board of Directors' meeting a number of important items were carefully considered and working committees appointed.

Undoubtedly the coming year will be a banner year for the Society from the point of view of actual accomplishments in advancing the knowledge and art of welding through research, extending its applications and also in the development of suitable standards.

Another record for attendance was broken in connection with the annual dinner of the American Welding Society. About 170 members and their guests enjoyed the excellent dinner and entertainment which followed. Great credit is due to the Dinner Committee for its efforts in making this event a huge success. Credit is also due to the donors of prizes and souvenirs, which helped enliven the occasion.

Annual Report of the President—Presented Annual Meeting, April 26, 1928

This the ninth year of the Society's existence has been an active one. The great activity in the welding field, as a result of rapid increase in the use of welding in all branches of industry, has had much publicity in both the technical and general press—all of which has helped to increase interest in welding matters and in the American Welding Society.

The following is a brief review of the various Society affairs in which our members will be most interested. Many of these matters are discussed in more detail in the annual reports

of our Standing Committees, which are rendered to the Board of Directors at this meeting, and which will appear in the JOURNAL in due course.

Membership

The Society had a total of 913 members in good standing on March 31, 1928, distributed among the various classes as given in the following tabulation, which also shows corresponding figures for the preceding year.

Class	Membership, March 31 1928	1927
Sustaining members (A)	47	51
Members (B)	343	310
Associate members (C)	299	262
Operating members (D)	210	226
Honorary members (E)	3	3
Student members (F)	11	2
Total	913	854

There was a gross gain of 239 members during the year and a net gain of 59 members. However, it is to be noted that the Operator Member grade (D) showed the greatest net loss (16), while the bulk of the gain was in the Member and Associate Member grades (70). Thus, while there has been a net gain of only about 6 per cent in the total number of members, that gain has all been in the higher grades.

Finances

The total receipts during the Society year ending March 31, 1928, were $32,875.96; the corresponding disbursements were $34,795.65. While the receipts were over $4,000 greater than for the preceding year, the disbursements were over $7,000 greater than those of the preceding year. This resulted in a deficit in the year's operations of nearly $2,000, whereas in the preceding year we had an operating surplus of about $1,000.

This excess of disbursements over receipts for the year is largely due to the cost of publishing the Instruction Manuals, which was considerably greater than was anticipated, and to the small sale of the Manuals, which has been much less than was expected.

Our reserve fund has been reduced from $8,681.93 to $6,762.24. $5,269.50 of which is invested in bonds.

Meetings

The usual two national meetings of the Society were held, the 1927 Annual Meeting in New York and the Fall Meeting at Detroit. As usual, the Fall Meeting drew the largest attendance—much the largest attendance of any meeting that the Society has held. It will be recalled that this meeting was held at the same time as that of the American Society for Steel Treating and two other organizations in the metal working field. Doubtless this had much to do with the success of our meeting, one session of which had an attendance of over 300. The success of the plan tried last year for the first time of meeting at the same time as the A. S. S. T. justified continuing the arrangement at the 1928 Fall Meeting at Philadelphia.

Experience seems to indicate that the Fall Meeting is the most popular one and one where social features are most appreciated. With that in view this Annual Meeting has been made a strictly business and technical meeting with only one social function. Our social activities will be concentrated in the Fall Meeting.

Reports indicate that all of the 13 Sections have had very satisfactory meetings throughout the year. The plan of having joint meetings with affiliated local sections is meeting with increased favor and experience has shown it to be a particularly advantageous one. It not only makes for a larger attendance but, what is more important, brings welding matters before outsiders, which is just what we want to do.

Sections

The 13 Sections of the Society are in a reasonably satisfactory condition. While no Sections have been added during the year, suggestions for the establishment of Sections at Atlanta, Ga.; Baltimore, Md.; Canton, Ohio, and Houston, Tex., have been made. None of these has yet developed sufficiently to meet the preliminary requirement which has been laid down, namely, that a proposed new Section must have at least 25 paid-up members, of which 15 shall be Members or Sustaining Members.

Journal

The total number of pages published in the JOURNAL last year exceeded by a very large amount the previous record, as shown by the following tabulation. The 40 per cent increase over last year is, of course,

largely due to the publication of the four Instruction Manuals. Incidentally, it is of interest to note that the first volume of the JOURNAL published in 1922 contained a total of 644 pages.

	Number of Pages Vol. 6	Vol. 5
Editorial	122	128
Technical	970	568
Advertising, etc.	232	236
Total	1,324	932

Annual Exposition

A Welding and Cutting Exposition in connection with our Fall Meeting has now become an established activity of the Society. Last year the experiment was tried for the first time of holding this exposition jointly with that of the American Society for Steel Treating. The experiment proved highly successful, both from the standpoint of the Society and the exhibitors. The A. S. S. T. exposition management handled all of the arrangements, thus relieving our people of all details in connection with the exposition. On the other hand, the Society received 12½ per cent of the total receipts from the 37 exhibitors in the Welding and Cutting Exposition so that a substantial contribution was made to the treasury of the Society. The exhibitors very generally expressed approval of the arrangement since it naturally provided a much larger audience than would otherwise be the case.

This arrangement is to be continued at the 1928 Fall Meeting to be held in Philadelphia.

American Bureau of Welding

The Bureau, which is the Research Department of the Society, has confined its attention during the year to a few problems of major interest to the welding industry and to the stimulation of fundamental research in the welding field.

The work on welded rail joints has been limited to investigations seeking to improve the seam welded type of joints and to measurements of stresses in various parts of rail joints under various service conditions and also under various test conditions. Some experimental work also has been done with a repeated-impact testing machine.

One of the most important investigations undertaken by the Bureau is that of securing fundamental unit design data to be used in the welding of steel structures. This investigation involves a very comprehensive series of tests, the program of which has been carefully worked out by the committee having the investigation in charge. The cost of the work is being underwritten by industry, and the funds for the first year's expenditures have been turned over to the National Research Council, which will act as the treasurer. The actual experimental work on the program in connection with the investigation will very soon be under way.

A joint research committee on welding as applied to pressure vessels has been organized under the joint auspices of the American Society of Mechanical Engineers and the Bureau. The committee has prepared a detailed program covering tests of tanks and which it is believed will give the information desired by the Boiler Code Committee of the A. S. M. E. and others interested in the administration of regulations covering pressure vessels of various kinds. A very important part of this program, as well as that of the structural steel investigation, is the formulation of standard procedures covering inspection, qualification of welders, technique of welding, etc. The development of these procedures will be a by-product of these investigations which should prove of great value. At any rate, they will be of immediate value to the various committees of the Society which have been organized to prepare Codes dealing with welding in various fields.

The Bureau has elicited considerable interest among a number of educational institutions in several fundamental investigations dealing with welding. Some of these fundamental researches which are being voluntarily carried out are effect of heat on parent metal adjacent to the weld (Carnegie Institute of Technology), metallurgical studies of welds (University of Toronto), studies of stresses in butt and tee joints (Rensselaer Polytechnical Institute and Catholic University of America), surface tension studies of molten weld metal (Lehigh University), study of welds at elevated temperatures (Leland Stanford University), and fatigue tests of welds (State College of Washington).

Instruction Manuals for Welding

The Instruction Manuals for the four classes of welding which have been in preparation under the auspices of our Educational Committee for several years were finally published during the year. The Manuals were published as supplements to the JOURNAL so that each member of the Society obtained them without cost. Extra copies were printed for sale as separate pamphlets and as one bound volume.

Unfortunately the cost of the publication of these Manuals proved much higher than was expected (approximately $2,800), and on the other hand the sales were less than was contemplated (approximately $1,100).

Nevertheless, this type of activity is a most important one, and it is to be hoped that the sales will ultimately defray a reasonable part of the cost so that similar efforts on the part of the Society will not be discouraged.

Welding Codes

It is very gratifying to report that organizations responsible for various Codes involving the fabrication of welded structures are turning to the Society for assistance and advice in connection with the application of welding and cutting under such Codes.

The Boiler Code Committee of the American Society of Mechanical Engineers has formally requested us to prepare and recommend a procedure for fusion welding of pressure vessels. A Society committee has been appointed on "Welding Code for Pressure Vessels" with instructions to prepare a Code for the welding of pressure vessels which will not only serve the purpose of the Boiler Code Committee but which can be made a general standard of the Society.

The Boiler Code Committee has also asked us to designate a Conference Committee which will cooperate with the Welding Sub-committee of the Boiler Code Committee in all matters dealing with fusion welding as applied to pressure vessels.

The Sub-committee on Welding of the Sectional Committee on Safety Code for High Pressure Piping of the American Engineering Standards Committee has also formally requested us to recommend a procedure covering fusion welding and cutting as applied to high pressure piping for all purposes—steam, air, gas, refrigeration, etc. For this purpose a Society committee has been appointed on "Welding Codes for Pressure Piping."

It is obvious that in the preparation of these Codes the Society will be fulfilling the purpose of its existence in a very practical manner. As a further effort in that same direction, a Society Committee has been appointed on "Welding Codes for Buildings" to prepare Codes dealing with welding as applied to building structures which can be used by all interested in such matters, including municipal authorities.

Conclusion

It is, I think, very evident to all of us that the Society has "arrived." It has acquired prestige among other technical societies and in industry. It is being looked to more and more as the responsible, organized representative of the general welding art as a whole. With this increased influence comes greater responsibility and additional opportunities to be useful to industry.

As I indicated a year ago, I feel that the Society has an unusual opportunity to become a very important and influential body—one which can be of great service in advancing the interests of all industry through the application of the welding processes. At the same time the Society can be a very remunerative investment for the commercial interests in the welding field which must necessarily provide the greater part of the funds which are so essential an element in the successful prosecution of a project of this kind.

Respectfully submitted,
F. M. FARMER,
President.

April 26, 1928.

Much Welding Used in New Yale Library

(*Taken from April 26, 1928, issue of Iron Age*)

Fifteen miles of steel columns will be electrically welded to form the book stacks of the $7,000,000 Sterling Memorial Library being built at Yale University. The book tower will consist of 18 stories, a total of 130 ft. high, and will provide space for 4,000,000 books. Eighty thousand feet

of steel columns will be needed to construct it.

Arc welding will be employed. The channels carrying the book shelves and the walkways are 5 in. deep.

G. D. Fish, Westinghouse Electric & Mfg. Co., is consulting engineer on welding.

A Convention Echo

(Reprinted from April 14, 1928, issue of Electrical World)

In the non-technical world it is freely accepted that engineering is a romantically absorbing phase of modern life. The glorious accomplishment of the seemingly impossible and the spectacular element in successive triumphs leave the lay mind in bewildered appreciation. There is, however, in this same non-technical world a definite impression that engineers, as individuals, are tremendous bores. Possibly it is because as a class they tend to do much and say comparatively little. When a technical meeting is over and the last listless word has been said the listener may well wonder if this reputed dullness of the engineer is not a very real characteristic, for inflectionless voices, muffled murmurings and the reading of quivering pages, interrupted only by furtive glances at the audience, are the rule rather than the exception. That the subject matter is theoretical, or involved, or specialized, or a part of one's every-day life, does not bar it from an interesting, or at least interested, presentation. It is said that one of the great actors of yesterday could, and did upon several occasions, recite the alphabet or multiplication table with true emotional values.

The speakers at the last annual meeting of the American Society of Mechanical Engineers were parties to an interesting experiment. A professional public-speaking coach was engaged by the meetings and program committee, and with the cooperation of a number of those who were to present papers a courageous and unusual effort was made to ameliorate the potential sufferings of the audience. This is something which should gain merit through repetition. There is one obligation which every one who speaks or writes should unfalteringly meet, and that is—to be interesting. It is not incompatible with accuracy, brevity or ability.

Long Welded Pipe Line for Springfield, Mass.

(News item furnished by General Electric Co.)

The longest welded pipe line in the East, the construction and installation of which involves many interesting and novel features, is now being built to supply water to the city of Springfield, Mass. To be known as the Little River water main, it will carry water from the Provin Mountain reservoir over a distance of seven miles to the city, dropping more than 300 feet in elevation and passing under the Connecticut River on the way.

From the reservoir to the west bank of the Connecticut River a single line of 54-inch and 48-inch diameter pipe is used. Two lines of 36-inch diameter each are laid under the Connecticut River and, from its east bank, a single line of 48-inch and 42-inch pipe connects with the present distribution system of the city of Springfield. The plate used in the pipe varies in thickness from 5/16 to 1/2 inch.

The pipe is made in 30-foot lengths from two 30-foot plates which are bent into half cylinders and automatically arc welded together. To facilitate joining sections in the field, the plates are so sheared that the pipe diameter increases slightly from one end to the other, thereby permitting the small end of one section to fit into the large end of the next section.

By the use of compressed air, the plates are held rigidly in position during the automatic welding process. Welding is accomplished by means of the multiple-arc process, employing two arcs, one following about eight inches behind the other. By using two travel carriages with a total of four arcs working simultaneously, a 50 per cent saving in welding time per pipe is effected over that necessary with one travel carriage and two arcs.

Each pipe section, after welding, is subjected to careful tests. A special machine which subjects the pipe to a given water pressure from within is used for this purpose. The pipe is then thoroughly cleaned and dipped vertically in an electrically heated tank of coal tar pitch varnish. This varnish coating protects the pipe from corrosion in service.

SECTION ACTIVITIES

Boston

The regular April meeting of the Boston Section was held on April 17, at 6 p. m. at the General Welding Equipment Company's plant, through the courtesy of Dr. A. Krebs. The main features of the evening were: (1) Metal Coating with Metal Spray-Torch. (2) Shaping Steel with Automatic Shape Cutting Machines. Interesting demonstrations were made. Mr. R. L. Binder, president of the Metals Coating Co. of America, and their representative, Mr. F. A. Barbey, were invited to show metal coating. This was a very successful meeting.

Chicago

The following nominees were appointed by the Nominating Committee.

For Chairman—R. G. Longwell, Link-Belt Co., Chicago.

For Vice-Chairman—H. E. Gennett, Chicago, Burlington & Quincy R.R.

For Secretary and Treasurer—Stuart Plumley, Gas Products Association, Chicago.

Directors for Three Years—K. R. Hare, C. H. Hollup Corp.; B. N. Law, Air Reduction Co.; G. Rose, Oxweld Acetylene Co.; O. T. Nelson, Pacific Steel Boiler Corp.

Director for Two Years—E. L. Mills, Bastian Blessing Co.; Director for One Year—Robert Malcolm, Chicago Eye Shield Co.; Director to Represent the Chicago Section at N. Y. Meetings of Society—W. A. Slack, Torchweld Equipment Co.

Los Angeles

The April meeting of this section was held on the 25th. This was the Annual Joint Meeting of the American Welding Society, Steel Heat Treating Society and Metallurgical Society. There was an interesting talk on "Heat Treating with the Acetylene Flame." Also Mr. W. R. Schuyler spoke on "The Metallurgy of Steel," and there was a picture, "A Journey Through the Bethlehem Steel Plant."

Northern New York

The Section will hold a meeting on May 10 at the General Electric Company Works in Pittsfield. At 2:30 p. m. an inspection trip will be made through the works to see applications of the various forms of welding. Dinner will be served at 6:30 p. m. in the Works restaurant. The charge for this dinner will be 75 cents. The meeting will be held at 7:30 in the Works Auditorium. Mr. F. P. McKibben will give an illustrated lecture on "Electric Welding of Steel Bridges and Buildings." Mr. W. L. Warner of the General Electric Company will give a talk on "Pressure Vessels."

Western New York

The regular monthly meeting was held in the Fillmore Room at the Hotel Statler at 8 p. m., April 17. This was a joint meeting of the American Welding Society, Society of Automotive Engineers, American Institute of Electrical Engineers and the Engineering Institute of Canada.

The afternoon of this date was spent in an inspection trip to the factories of the Curtiss Aeroplane & Motor Corp. and the Consolidated Aircraft Co., including a visit to the Buffalo Airport; 275 people were on the inspection trip. Following the trip there was a dinner at the Hotel Statler, the evening meeting starting at 8:00 o'clock, with an audience of some 475 people.

The first speaker was Mr. H. C. Ritchie of the General Electric Co., Schenectady, who delivered an interesting and instructive paper on the "Developments of Airport Lighting," illustrated by lantern slides. The next speaker was Mr. C. Roy Keyes, president of the Curtiss Aeroplane & Motor Corp., who spoke on the subject of "Recent Progress in Aeronautics," he emphasizing the fact that at the present time there are some 75 manufacturers of airplanes, with a large number of manufacturers of aircraft parts and accessories, while only a few years ago there were but some 5 or 6 aircraft factories.

Mr. Keyes' paper was illustrated

by moving pictures. These showed the tests that are given to all Army and Navy airships, also the take-off of a large number of battle planes for an imaginary scouting trip, showing the planes in the air, in battle formation.

Mr. Marsden Ware, also presented an interesting paper on "Research in Aerodynamics by High-Speed Motion Pictures," the film being loaned by the Aeronautic Division of the A.S. M.E. and by Baron C. Shiba, director, Aeronautic Research Institute, Tokyo Imperial University.

Mr. Ware explained to the audience that the ordinary moving picture is taken at the rate of 16 per second, and he carried us through the various stages of moving pictures, some of which were taken at the rate of 42,000 per second, these showing the action of wind currents on various portions of an airship, also showing a bullet from a pistol slowly pushing itself through an incandescent lamp bulb.

These joint meetings, although not confined strictly to welding matters, always result in a very large audience, but it is the intention of the Secretary and Chairman that the next few meetings will be devoted strictly to welding subjects, and the first few meetings to be devoted to structural steel welding, in which there is now developing a great amount of interest among designing engineers.

The list of officers for the year 1928-29 have been nominated; they also have accepted the nomination. They are:

Chairman—F. L. Rodgers, Oxweld Acetylene Co.

Secretary and Treasurer—Gideon W. Swan, J. A. Roebling's Sons Co.

Representative to A. W. S.—C. H. Lockwood, General Electric Co.

Chairman Meetings and Papers Committee — Robert Siemer, Allan Mfg. & Welding Co.

Chairman Membership Committee—R. W. Bannar, Roote Neal & Co.

Philadelphia

On Monday evening, April 16, the Philadelphia Section held a very interesting meeting. Mr. W. M. Dunlap of the Aluminum Company of America spoke on "Welding of Aluminum." This was a very interesting paper, and the meeting was well attended.

San Francisco

The regular monthly meeting of this section was held on Wednesday, April 25. The General Electric Company provided the program for this meeting. Mr. M. Rhine and Mr. C. R. Owens were in charge of the program. The topics were "The Tire of Steel" and "Fabrication of Machinery by Welding." The following are the names that appeared on the official ballot for election.

Chairman—R. H. Atkinson.

Vice-Chairman—K. V. Laird.

Treasurer—H. W. Saunders.

Secretary—H. W. Saunders.

Executive Committee Member (3-year term)—C. S. Smith.

Executive Committee Member (2-year term)—N. W. Thompson.

Section Rep. National Board of Directors—J. C. Bennett.

New York

The New York Section will hold its regular monthly meeting on May 15, at 8:15 p. m., in Room 2, 33 West Thirty-ninth Street, New York City. Two papers will be presented, one by Mr. W. R. Hulbart, of the Metal & Thermit Corporation, on "New Developments in Reclamation Work with Thermit," and the other by Mr. J. F. Lincoln, vice-president of the Lincoln Electric Company, on "Electronic Tornado." Both papers will be accompanied by lantern slides.

EMPLOYMENT SERVICE BULLETIN

POSITIONS VACANT

V-42. Experienced Gas and Electric Welder wanted who is capable of taking charge of department in a production shop. Must be practical welder as well as a good supervisor.

V-43. Need structural steel arc welder. Give experience, age and salary desired.

A Discussion on Standardization of Construction Welding

and

Standard Specifications for the Qualification of Construction Welders*

by

Committee on Standards for the Qualification of Welders†

THE work of this committee is a part of the work outlined in an extensive program of the American Welding Society and affiliated bodies that looks toward the promulgation of general standards for construction welding.

These general standards will give consideration to the following factors for each branch: Design for welding, selection and inspection of weldable materials, qualification of welders, supervisors and inspectors of welding and to practical testing of welded structures.

General Program of Standardization

The following phases of this general program are now under way by regularly appointed committees:

1. The welding of structural building steel is being researched by the Structural Welding Committee appointed by the American Bureau of Welding.

This committee has its experimental program determined, has completed a pilot test for its main program, and is about ready to undertake its principal work.

2. The Committee on Building Codes, under the American Welding Society, has been appointed for the purpose of rendering assistance to regulatory bodies, such as State and municipal building departments that request help from the American Welding Society and the welding industry, in the revision of codes so as to permit application of welding and cutting thereunder. This committee is also to endeavor to have modified such existing ordinances in building codes that unduly restrict welding and cutting.

3. The Committee on Nomenclature under the American Welding Society is undertaking to determine appropriate standard nomenclature

*Presented at annual meeting of A. W. S., April, 1928.

†Committee members: H. H. Moss, Linde Air Products Co. and A. M. Candy, Westinghouse Elec. and Manufacturing Co.

for welding and cutting, and has prepared a bulletin, which will soon be submitted to the industry for consideration.

4. An Educational Committee of the American Welding Society has prepared instruction manuals covering the fundamentals of the arc, gas, resistance and thermit welding processes. These manuals have been written to meet the needs of welding students.

5. The Committee on Standards for the Qualification of Construction Welders, under the American Welding Society, is undertaking to write standard specifications for qualifying welders, supervisors and inspectors for the important branches of construction welding.

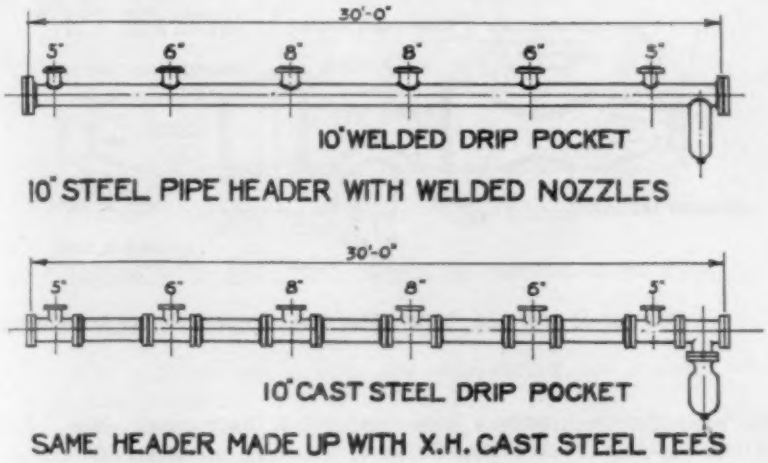


FIG. 1

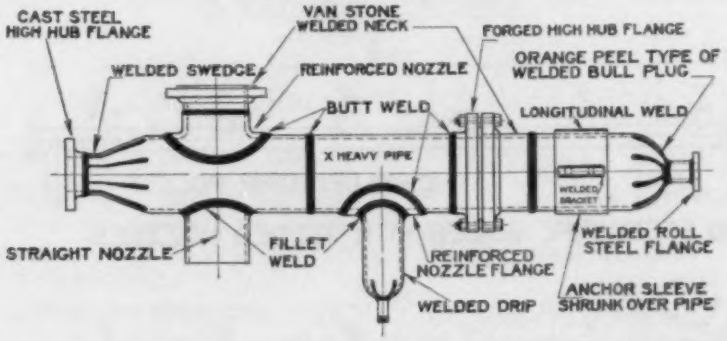
6. The Boiler Code Committee under the American Society of Mechanical Engineers, working jointly with the American Bureau of Welding, is soon to undertake a series of research tests to determine safe design and construction practices for welded unfired pressure vessels. As a step toward this end, the Boiler Code Committee has requested the American Welding Society to prepare for the committee's consideration a tentative general procedure specification for the construction of unfired pressure vessels and which shall embrace proper methods for the design of vessels, suitable materials for welding, qualification of welders, applicable welding technique, and proper tests for welded vessels. A separate subcommittee has been appointed to attend to this request.

In addition, the American Welding Society has received a request from a sub-committee of the Sectional Committee preparing the Safety Code for Pressure Pipe, under the American Engineering Standards Committee (sponsored by the American Society of Mechanical Engineers) for tentative specifications for the safe welded construction of industrial piping. The code is to include the following classes of piping: Power, hydraulic, gas and air, refrigeration and oil. A subcommittee has been appointed to prepare these specifications.

Standardization in Qualifying Welders

For nearly all of these assignments and requests there will be required to be prepared standard procedures for the qualification of the respective welding personnels. For each, the requirements will vary in some respects, making it necessary to write individual supplements for each general procedure offered or promulgated by the several committees.

In view of the projected research work of the Structural Welding Committee and also of the Boiler Code Committee, the Qualification Committee is planning to defer the preparation of supplements therefor until



TYPICAL DETAILS OF HIGH PRESSURE POWER PIPING

FIG. 2

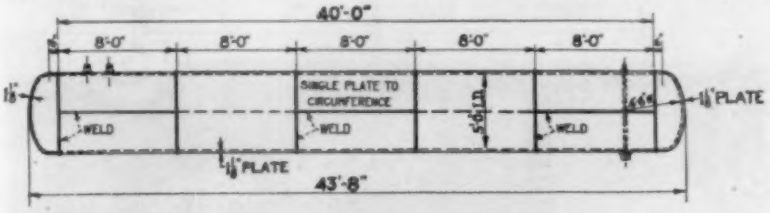
these respective committees have completed their researches. In the meantime, it has devoted its efforts to working up tentative standards for qualifying the welding personnel for industrial piping, thereby immediately contributing to the work of standardization for one of the three very important branches of construction welding.

A general outline for qualification supplements has been prepared for presentation at this meeting. However, before doing so let us give thought for a moment to the implied meaning of "Standardization" as it refers to welding. In the final analysis, as we all know, standardization is a matter of economics one way or another. It implies that a uniform method or practice for doing a certain work has been, or is to be devised, and in the most economical manner consistent with sound engineering and safety. It is generally understood in speaking of Standardization that the practices or methods set forth are entirely within the ability of the average trained operators or mechanics related to the particular industry to which the standards apply.

With regard to construction welding, at the present time average manual practices for any particular developed branch, are far from being uniform. Where there has been due regard to the technical factors in welding, very satisfactory and uniform practices have resulted. On the other hand, there are the many cases where the accepted practices analyze to mean that the character of the welding merely suffices to meet

certain local conditions. The work very often falls below the minimum requirements for sound welding. Welders working under such conditions may fail entirely to qualify for another branch of construction welding, even though having a number of years of welding experience. The question arises in this work, how should average skill be defined for the various applications involved? Shall we seek for precedents of manual skill, or shall we look for a basic principle?

It is held that if welding is to advance generally and reliably into the fields of construction it must be executed under standard methods, devised upon the fundamentals of sound engineering and thus conform to an important principle of standardization. If we work from this angle, it becomes necessary to determine the engineering requirements that are to be placed for each branch, whereupon we can proceed to write speci-



ASSEMBLY DESIGN OF A BUTT WELDED HIGH PRESSURE TANK

FIG. 3

fications that will answer to both the engineering and manual sides of the particular problem.

The concluding section of this preliminary survey is devoted to a brief review of the general fundamentals of sound welding and logically opens with *Design for Welding.*

Designing for Welding

Fusion welding affords a means of joining the elements of a metal structure that produces a molecular union at the junction. If the parts have been properly designed, this permits of direct transfer of the imposed stresses in the elements to other contiguous parts. Where full practical advantage of this principle has been taken, the greatest economy in materials is obtained, for not only are joint details minimized but the resultant absolute joint rigidity, by its favorable influence on the strength of compression members, permits of the use of a lighter section. Welding also provides for the utilization of the gross section strength of tension members, as it avoids the use of rivets, pins or bolts, otherwise necessary.

Full or adequate strength at the junctions, as may be desired, is readily obtained by the proper preparation of the joints to be welded, by using suitable welding rod and properly qualified welders. It is necessary, of course, to analyze the operation for contraction and expansion effects, at and away from the points of heat applications, and to provide such means, either directly or indirectly, to counteract or remove them en-

tirely. The purpose of this report does not provide space for a detail discussion on welding design and therefore only some of the broadest principles have been touched upon. In every day practices of applied welding we find many types of welded joints, not all of which conform to the foregoing principle of stress transfer, and which are giving satisfaction. The variation that such joints introduce into the problems of welding must be taken into account in the Qualifications Specifications.

To illustrate in a very broad manner, the trend of welding design as practised by some of our leading construction enterprises, for a few kinds of construction, several assembly designs have been included.

Fig. 1 compares the design of a welded 10 in. steel pipe header with that of a similar header made up with flanged cast fittings.

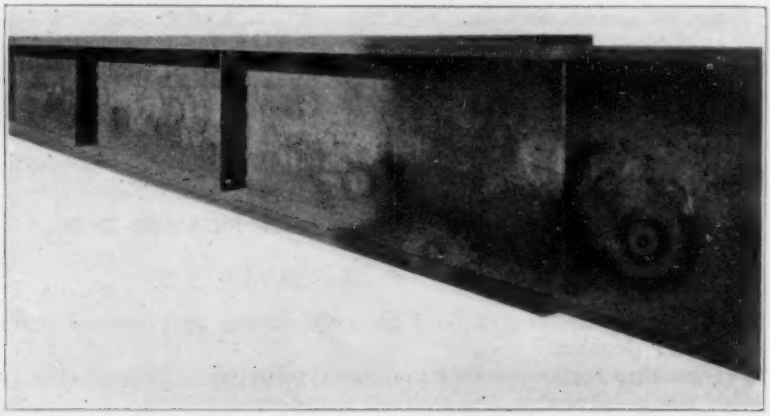


FIG. 4. WELDED PLATE GIRDER—NOTE ABSENCE OF ANGLES

Fig. 2 illustrates the principle of direct stress transfer applied quite extensively to high pressure steam header details.

Fig. 3 illustrates a welded assembly design for a simple pressure vessel, which utilizes the butt joint throughout for the plates and heads.

Fig. 4 shows how this same principle as applied to the construction of plate girders. Here the fillet weld is used exclusively.

These are typical welding designs from the standpoint of assembly. The design of the joints for these structures is likewise plain. For fillet welding there is only required that the materials be squared. For butt welding of materials thicker than 3/16 in. it is necessary to bevel the edges to be joined so as to provide for full penetration of the weld. Typical joint preparations are shown in Figs. 5 and 6.

Weld Dimensions

This leads to the subject of weld dimensions, a factor in welding design that deserves the careful study of the designing engineer. It calls for knowledge of the unit working strength of welds, which de-

termines the depth or throat dimensions of welds. When low carbon, soft iron welding rod is used the unit strength of a weld made therefrom may or may not be equivalent to that of the material welded. This depends upon the properties of the material, usually the carbon content. When the unit weld strength is lower increased strength can be obtained by reinforcing the weld. Welding rods of higher strength can be used, whereupon a reinforcement is unnecessary. However, a certain amount is generally specified to insure full dimension welds.

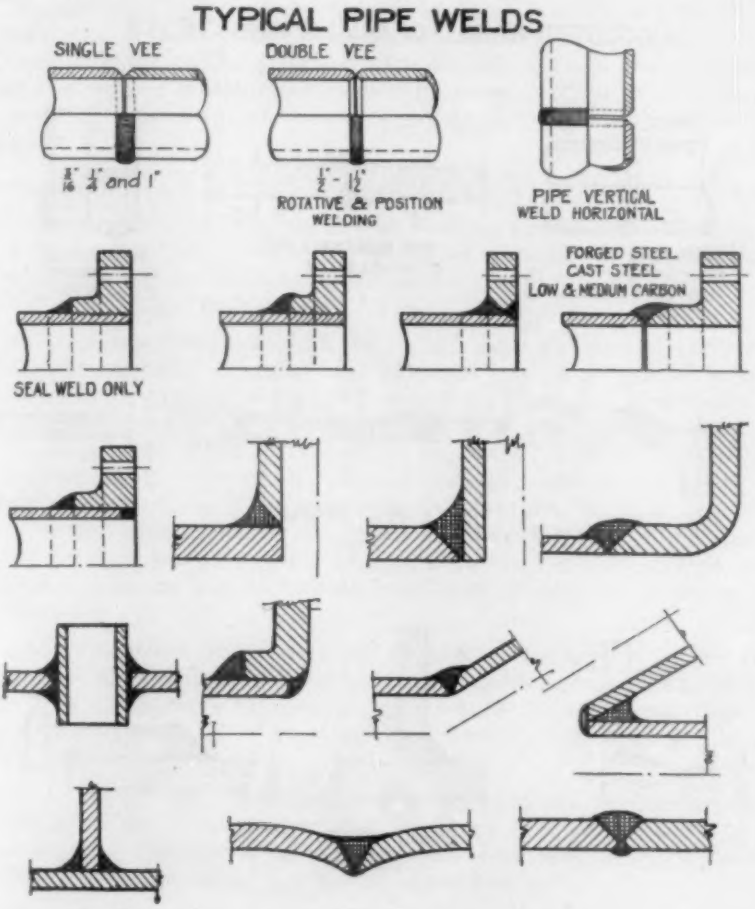


FIG. 5

Dimensions of fillet welds are determined by the strength requirements through the throat, which is the critical section of a correctly made fillet weld. Variations in strength of fillet welds then are obtained by changing the width of the throat.

Fillet welds for lapped joints must have throat dimensions greater than the thickness of material, if full strength at the joint is wanted.

Too great a reinforcement should be avoided as the strength of any amount above that actually required cannot be utilized, and only adds unnecessary expense to the joint.

Selection of Materials

Closely related to design is another fundamental of sound welding, viz., suitable or weldable materials. We cannot expect a satisfactory result if this factor is out of balance. The materials to be welded should be tested for weldability or for the defects that operate to im-

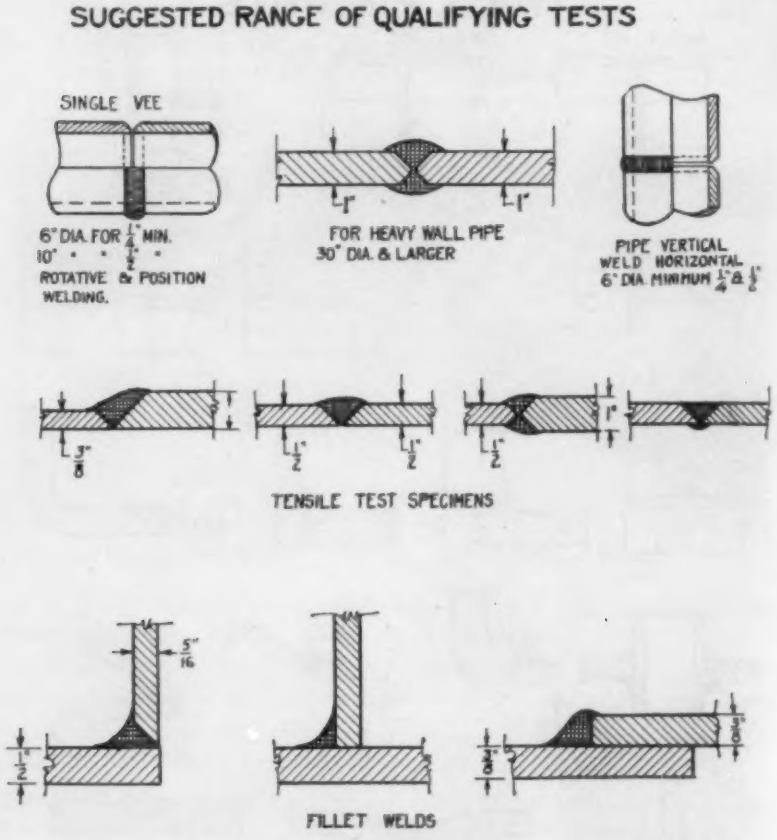


FIG. 6

pair the strength and density of the weld and cause difficulties during the welding operation. For the present we have only to consider the low carbon steels and irons, the carbon not exceeding 0.25 per cent.

The defects in the commercial steels and wrought iron, which operate against sound welding, consist mainly of dirt in the form of slag, laminations, and in some cases, segregated carbon. Where any of these defects occur in an appreciable amount, the materials may be unsuitable for welding.

A good test for weldability consists of melting, under a suitable flame, a specimen taken from the material provided for the work. Weldable metal in the molten condition will flow quietly and have a smooth and clean appearance. Where the steel is laminated, the melting operation will expose these strata to the inspector. Dirt or foreign matter in the steel generally shows up in the form of small white specks or causes undue sparking.

Under inspection of materials we must include the welding rods, electrodes, or filler materials that are provided, which may be of such poor quality or of incorrect chemical properties, making it difficult and in some cases, impossible to produce a satisfactory weld. We must also give consideration to the selection of the welding tools and equipment so that the welder is not handicapped by irregularities of this source. This requires knowledge of the functions of welding tools and welding equipment.

Supervision

Welding supervision is a function of welding operations that deserves our careful attention. Upon this we must depend for an intelligent interpretation of the welding specifications and the direction of the welders performing thereunder.

A welding supervisor should have a good general working knowledge of the fundamentals of sound welding and the technique of welding applying to the particular branch under his direction. Preferably, he should have practical experience in handling the tools of welding and in depositing weld metal. One of his important responsibilities is to see that the joints to be welded are accurately prepared and set up for welding. Where care is exercised in this respect, welding is accomplished in the shortest time, the welds are invariably of better quality and the finished work is neater in appearance. For piping, this detail is facilitated by the aid of flexible templates, if accurately drawn and transferred.

Wherever possible, the supervisor should see that the work is set up in a manner that will enable the welding to be done in convenient position. It is not always necessary for a welder to stand continuously. Special clamps and jigs often simplify a welding operation and reduce costs.

It is the supervisor's responsibility to see that the welders are properly qualified for a particular class of work and periodically tested. He need not be required to test the finished work, but he should be kept informed of the results of the testing department.

Inspection

In the light of standardization, inspection, if competently performed, will enforce the rules and regulations laid down in our standards and therefore is a factor that performs a very vital function. As the use of welding in construction increases, we will have to depend more and more upon agencies such as commercial inspection laboratories and engineering concerns specializing in inspection to perform the services

of welding inspection as is customary for other lines of construction work. Then, too, there will undoubtedly be a need for a large number of welding inspectors for building departments. Insurance companies will likewise find it necessary to add additional welding inspectors to their staffs or otherwise develop personnel for this service. All in all, there is quite a broad angle to this factor, especially when it is considered that a competent welding inspector should be one qualified to check not only the manual results of welding but also the construction practices leading up to this and be able to direct the testing of the completed structure in many cases. Inspection and supervision is the subject of another paper and will not be dwelt on further, except to say that it is the opinion of this committee that we should undertake to define means and ways of qualifying inspection and supervision for competency.

Qualification of Welders

The importance and necessity of qualifying welders, for a specific work, has been demonstrated time and again if satisfactory results are to be obtained. Requiring that this be enforced upon the construction industry at large is not unreasonable. It is merely a mile post that will mark the gradual elimination of the semi and unskilled welder from important work. If generally imposed, and this I am sure we must support, it will render a hardship on a certain number of welders applying for work under the jurisdiction of our standards; but, on the other hand, it will eventually be the source of benefit of all welders and certainly to the welding industry at large.

It has been proven that the workmanship of welders can be developed consistently to measure up to the requirements of sound welding practices by the means of proper qualifying tests. When first imposed for a particular welder they serve in a great measure as a training episode. Thereafter in the fashion of check tests, they serve to round out his workmanship and refine his technique.

For the employer the advantages obtained from this are manifold. Dependability of welds, which protects his products and safeguards his reputation is probably the greatest of the benefits derived thereby. Neat workmanship and orderly use of the process of fusion welding are points of merit. Then, too, the cost of welding is kept to a minimum through the employment of skilled mechanics thereby eliminating rejections or claims chargeable to poor workmanship.

Scope

As previously stated, the committee plans to work up, first, tentative procedures for the welding of industrial piping for reasons already explained. As this branch of construction welding is today by far the most highly standaradized, there is a large amount of data available which can be directly used in our standards. There are factors, however, in this branch which must be very carefully studied before they can be determined in the standards, particularly where high pressures and temperatures prevail, such as weld ductility and the quality of the base materials.

In this branch of construction welding we have the following general classes of piping:

1. Gas and air piping.
2. Oil piping.
3. Steam heating and power piping.
4. Water piping.
5. High pressure hydraulic piping.
6. Refrigeration piping.

It may be found necessary to issue separate bulletins for each of these as each presents problems uncommon to the others. Especially is this so with regard to shop and field welding practices.

In regard to the qualification of welders for the welding of structural building steel, this committee will be guided mainly by the recommendations of the Structural Welding Committee. They will, no doubt, advise this committee what this branch of construction welding will demand of the welder. It will then befall this committee to devise means and ways to practicalize their requirements. Fortunately, however, a great deal of work has been done along this line and as soon as the Structural Welding Committee's tests are completed and analyzed it should not take undue time to prepare the qualification tests for the permissible applications.

For pressure vessel welding we have a problem before us of an entirely different nature than either of the preceding ones. The designs are extremely varied in nature and introduce many kinds of joints not encountered in piping. The variations and thicknesses of base metal are probably as numerous as in structural building steel welding. Then, too, the operating requirements of pressure vessels are in many cases extremely hazardous in character. This branch of welding requires the most exacting welding procedures and therefore demands the greatest skill on the part of the welder. Qualification tests, must be cautiously devised for both the welders and the supervisors or inspection personnel. This work will, no doubt, proceed jointly with that of the Committee on Unfired Pressure Vessels.

Under the subject of scope we will probably want to consider as this work progresses the preparation of standard qualification tests for the welding of machine frames and housings, certain process apparatus, storage tanks, and other important objects in which welding is prominently employed. Then, too, there is for consideration the welding of copper, brass, aluminum and certain alloys, which are being satisfactorily welded today. This work, as will be seen, can go on indefinitely if we desire to develop standards for the entire range of applied construction welding. It is obvious, however, that we have sufficient to do to work up standards for low and medium carbon steel and wrought iron base materials for the present.

Suggested Outline for Qualification Procedures

For this meeting the committee has prepared for your consideration a brief outline for a bulletin dealing with the qualification of welders for industrial piping. A survey has been made for the types of welds

usually encountered in present-day construction practice and these have been assembled in Fig. 5. It will be observed that there is a wide variation of joint design both in regard to character of the welds and to the dimensions of the parts joined.

The question now arises how far shall we attempt to go in proving the welder's ability satisfactorily to produce these various types of welds, prior to engaging them on major work. A simple butt and fillet weld test would seem to be insufficient. Many of us have had the experience of witnessing the futile attempts of certain welders to weld important fittings, headers and piping accessories satisfactorily, although being well qualified to make line welds. In most welding shops and field welding operations, it is customary to qualify certain welders for the unusual applications. Where this is not done difficulties are usually encountered.

It is the growing belief of this committee that all pipe welders might not have to be qualified for all types of pipe welding construction, and if this would be acceptable we could devise qualification tests of two types, one for the welder to be employed on straight line joints only, the other to embrace the full range of welding encountered say, in pumping stations and power piping installations. Only the fully qualified welders would be satisfactory for certain branches of piping, such as that for refrigeration, air, high pressure hydraulic, and steam power plant service, which generally consists of a unit of miscellaneous short runs of piping having numerous fittings and specialties not so prevalent in oil, gas and steam transmission piping systems where the majority of the welding may be of the simple butt or fillet types.

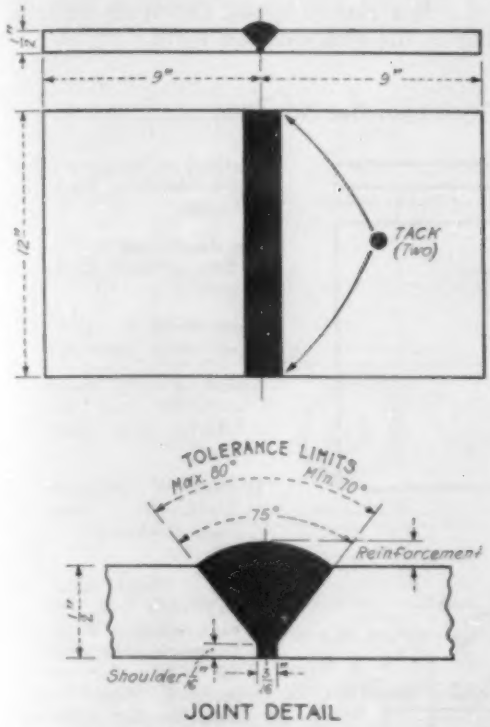
For instance, to determine the welder's ability to weld power plant piping or gas and oil pumping station piping satisfactorily, the qualification tests should embrace the range of tests that contain sufficient of the variables to test his general ability to make the welds encountered in a complete system of this character.

Fig. 6 suggests a range that should determine his ability. It will be noticed that the Fig. 6 includes test for vertical and horizontal applications of position welding as well as flat and overhead applications. In the field it is often demanded of the welder that he make welds in this manner and for such there is required additional skill on his part, especially if the metals joined differ appreciably in thickness and area. Welds of this kind, if properly made, may easily be kept free of laminations and oxides. Horizontal welds in Veed joints must be checked for thorough fusion along the upper side of the joint.

The cost of qualification, especially when a number of welders is involved, may develop an appreciable item of expense. This cost must be charged to the work. However, compared with the economies of welding either in first construction cost or later in operation, this expense will seldom be of importance.

The question also arises whether we should require a welder to demonstrate his ability to make a satisfactory weld joining commercial pipe steel to cast steel. Cast steel nozzles and flanges are frequently

utilized in the welded construction of piping and it is possible that variations in chemical composition of the two materials might offer some dfficulty to a welder not having previous experience. Usually where cast steel parts are utilized the adjacent welds are subjected to appreciable stress, therefore it would seem advisable to qualify the welder for this particular detail.



Single "Vee" Welded One Side Only

Number of weld layers —two.

Amperes average—
200 in flat position.
175 in vertical.

Penetration—100%.
Reinforcement—
20% of Plate Thickness.

Size of Welding Rod
3/1 6".

FIG. 7. DESIGN OF TEST PLATE FOR QUALIFYING ELECTRIC WELDERS ON BUTT WELDS

In setting up standards for butt welds we can no doubt utilize to a great extent the practices set out in the procedure specifications prepared by the Structural Welding Committee for their test program. These procedures determine the details of beveling the joints for both oxy-acetylene and electric welding, the shoulder dimensions, spacing, reinforcement and other weld dimensions.

Fig. 7 reproduces the design of and specifications for, standard qualifying test plates for electric single "V" butt welds, as set forth in the Structural Welding Committee's Specifications.

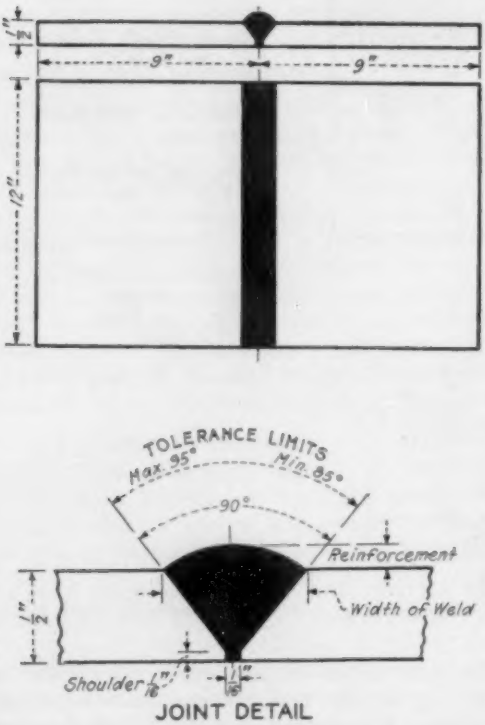
Fig. 8 reproduces from the same specifications, the design of and specifications for these plates for oxy-acetylene single "V" butt welds.

Similarly could be shown from the same specifications, standard test specimens for fillet welds.

Fig. 9 reproduces a diagram from these specifications showing how the tensile coupons are to be obtained from the welded plates.

The welding specifications for these plates will stipulate a maximum time in which to make the weld. This is quite important for it determines the welder's ability to produce a satisfactory weld at a commercial rate of speed. It is usually very easy for a welder to make a sound weld when he is allowed plenty of time, but production practices require that welding progress at a fair rate of speed, therefore we must set a maximum time for welding in the qualification tests.

Single "Vee" Weld from One Side Only



Method of Welding—Forehand or backhand.

Reinforcement—20% of plate thickness.

Penetration — (Full or 100% approx.)

Speed—For ½" metal —2 ft. per hr. (flat). 1½ (vertical).

Width of Finished Weld.—2½ times plate thickness.

Note: Plates shall be firmly clamped to a suitable table. In spacing the joint for welding, an allowance must be made at the opposite end of the joint to that where the welding is started to provide for contraction, for otherwise the joint edges along the 1/16" shoulder will overlap before the weld is completed. An additional spacing of between 3/16" and 5/16" is necessary, depending on the rate and method of welding.

FIG. 8. DESIGN OF TEST PLATE FOR QUALIFYING GAS WELDERS ON BUTT WELDS

It may be advisable to omit the standard flat plate test when qualifying pipe welders and obtain the standard A. S. T. M. tensile coupon from a section of welded pipe. This is a common practice with many concerns and may be adequate in every respect.

For fillet weld tests it is proposed to arrange a series of tests that

will determine the welder's ability to penetrate, fuse and produce welds conforming to specified dimensions, together with the standard requirements for weld quality in general over a number of variations of even and uneven thicknesses of base metal.

It is planned to include the photographic reproductions of acceptable welds from the standpoint of weld quality and dimensions as a means of guiding the welder and the management. This feature, it is believed, should also be fully included in the inspection manual.

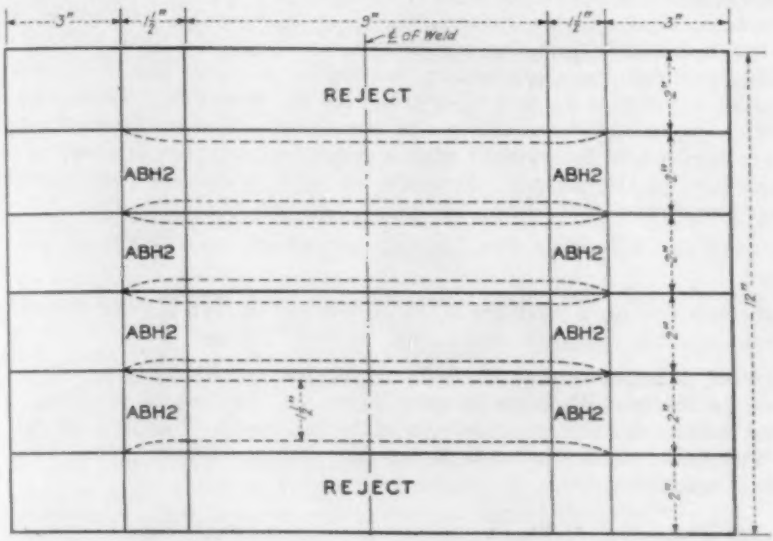


FIG. 9. DIMENSIONS OF COUPONS TO BE CUT FOR QUALIFICATION TEST OF WELDERS

The committee is not yet prepared to discuss with you the details of the feature of weld ductility. It believes, however, that weld ductility should be given serious consideration in our procedures and an attempt be made to evaluate it properly for it is an important factor of a welded joint in many classes of piping.

Attention also will be given to the practice of weld tacking. Wherever tacking is employed for temporary assembly either in the form of a small tack or as an increment of a final weld, certain precautions are necessary on the part of the welder so as to avoid a weak point in the final weld. In many cases tacking is hurriedly done and often by a different welder than the one making the final welds. Both operators should be required to employ correct practices for this operation, the former conforming to standard practice for producing welds, the latter employing well defined methods for rewelding or closing out a previously made weld. The methods for this latter operation can be clearly defined.

The weldability and general properties of base metal and filler materials for welding is a very important factor in the qualification of

welders. Time does not permit of a proper discussion of this factor, but from the standpoint of standardization it becomes necessary to emphasize the importance of the proper selection of these materials and to point out the difficulties encountered in welding where unsuitable materials are used. Most of us are aware of these difficulties. However, it would seem that a splendid opportunity presents itself in these proposed standards to bring out these factors in welding, forcibly. Then, too, there are certain ways in which commercial steel products can be used to advantage when welding them, which is not generally appreciated. As an illustration it is always better practise to locate important nozzles in lap-welded pipe so that the welds will not encounter the manufacturer's lap weld, and again, in welding double wall piping care must be exercised in thoroughly welding the inner wall of metal at a joint so as to properly utilize its strength. These characteristics might well be noted in our standards. The welding of nipples satisfactorily into heavy wall piping requires a certain amount of care on the part of the welder. It might be well to include this operation in our standards.

Rewelding injects another factor for which specifications are required.

Safe but adequate methods must be worked up for testing the piping systems and the sections containing welded fittings.

Correct practices must be defined for increment welding, or as is known in Eectric Welding Nomenclature as Multi-Bead welding, employed where the thickness of the material approaches and passes ½ in. Provision must be made to qualify the welder for this type of welding operation.

Physical Properties of Welds

This is another subject which the committee prefers to discuss in detail at a later time. It has not had opportunity to carry this matter properly to a point warranting public presentation. Whether we should adopt, say 40,000 lb. per square inch for a particular weld, or 60,000 lb. per square inch as the minimum tensile strength in a test coupon, depends to a great extent upon the nature of the work and requirements of the weld under service. It would, no doubt, be generally acceptable and desirable to require that the physical properties of the weld compare favorably with that of the base metal, or at least require that the deposited metal have sufficient strength in the fashion of commercial welds to develop the full strength of the material joined. This is all that engineers could demand of welding.

Conclusions

The above outline includes only the general factors common to qualification specifications in general. The manner in which each is to be worked into the separate bulletins will depend, of course, upon the conditions encountered in each division of industrial piping for which standards are being developed. In addition there will be required many supporting details, but these have to do with welding practices

of which we are all more or less familiar and have been purposely omitted in this report.

What the committee is most desirous of obtaining at this time is a general criticism of the tentative outline just presented. It invites a general discussion of the active part of the report and will be very glad to consider any suggestions which the members may wish to make, either during this meeting or later. As result of such discussion, the committee will have the consensus of your opinion as to the essentials for the qualification specifications and particularly as to the extent you all feel we should go to insure the competency of welders.

We must determine a policy before we can logically proceed to write the many standard qualifying specifications being called for.

Electric Welding of Steel Pipe

Training of Welders and Welding Procedure*

E. E. Shanor†

ELECTRIC welded pipe is being used more and more in place of riveted pipe in hydraulic installations and pipe lines for water supply purposes. It has decided advantages over other kinds of pipe in cost and in carrying capacity. Electric welded pipe is also being used for gas mains in connection with by-product coke oven installations. Within the last year it has invaded the field of lap welded pipe for conveying natural gas from the enormous gas fields in Louisiana and western Texas to markets in distant cities. The use of electric welded pipe is no longer an experiment, and in all future installations it will compete on, at least, an even basis with other kinds of pipe.

In mass production of pipe, dependence is not placed upon the skill of the individual welder. Automatic machines, improved weld rods, perfected methods of supplying current, with a proper welding procedure, have to a large extent eliminated the requirement for unusual skill on the part of the welder. This is especially true because in the making of pipe nearly all welding can be done in a horizontal position as the pipe is so designed that in general all seams will be longitudinal. It is further to be understood that the method of training and testing welders in a large manufacturing plant, where each man is under the constant supervision of his foreman, is materially different from that required for welders who are doing isolated jobs around the plant or in the field where each man is virtually on his own responsibility. It will be noted that in all manufacturing plants which turn out a product into which welding enters, the reliability and perfection of the weld is seldom questioned. For instance, no one questions the welding on his automobile nor does anyone object

*Presented as a discussion of Committee Report on "Qualification of Welders," given at Annual Meeting, A. W. S., April 26, 1928.

†Vice-president, Petroleum Iron Works Co., Sharon, Pa.

to welded transformer tanks, and welded steel barrels are universally used. Instances can be cited beyond number. All of which goes to prove that where a manufacturer installs the proper facilities, makes an intelligent study of his problem and attacks it with an honest purpose, there is little question but that the problem of welding can be completely solved, and, if not solved, the manufacturer will be the first to abandon its use.

In such a plant there is always a number of younger men who wish to learn welding. In our plant we believe it is of advantage that a welder understands thoroughly the fabrication processes involved in the finished product. For this reason the apprentice in welding is required to work at miscellaneous jobs around the shop for possibly six to eight weeks, during which time he will be under observation.

His relations to his fellow workmen, his inclination to work honestly, and his ability will be carefully observed. This first period will discourage anyone who does not honestly wish to learn to weld. He must then learn as a helper to fit up his work and assemble his materials. After becoming familiar with this he will learn to use the pneumatic caulking and chipping hammer, and will be assigned to a reliable welder as an assistant. He will also spend a period on the testing machine, as nearly all pipe work is given a shop test. By this time the foreman knows whether it is worth while attempting to make a welder in the particular case. If the applicant is successful during this part of his training, he is given some test pieces on which to work. The welded test pieces are cut to the proper size, given bend and pull tests, and broken in two in the weld so that he can judge the quality of the work and progress that is being made. It is required that each welder makes test pieces which are workmanlike in finish and which will bend 180 deg. around a pin whose diameter is about five times the thickness of the plate, and under tensile test will break outside of the weld, and that the deposited metal shows a clean fracture free from blowholes and inclusions. Such a welder is then passed along and used on less important work. Each welder's work is marked, so that when tested any defects can be called to the attention of the party responsible, and unless the welder shows proper pride in his work, as evidenced by his desire to avoid trouble on the testing block, he is no longer retained. After learning to weld by hand he is given a course of welding with the automatic equipment, and becomes a finished welder. In case an experienced man is hired, who is unknown to the foreman, he is required to produce test pieces and work up under observation until his skill is established.

The welding procedure in our shop is as follows: The plate is planed accurately to dimensions and a proper welding groove formed. Bevel shearing is not satisfactory, as it is found that a much better welding job can be produced if the groove is to uniform dimensions, which cannot be secured by shearing. We use what is equivalent to a single V groove. The metal is deposited in layers of about ¼ in. thickness or less, each layer after being deposited is vigorously peened

with pneumatic hammer by a workman other than the welder and who inspects the weld after peaning. The weld is then wire brushed and freed from scale and dirt, when a further layer is deposited and peaned until the weld groove is filled. The last layer is not peaned. The weld deposit at the bottom of the V is chipped out from the opposite side and a bead or root weld is formed on the inside. There are many advantages in this procedure. It is unquestioned with us that in pipe work, or any kind of welding, a lap welded seam is not to be considered. The preparation of the plate for double V weld is expensive, and with a double V weld the penetration and quality of deposited metal frequently is not good at the bottom of the V, which is the center of the weld. With a single V weld, the bottom of the V is chipped out and re-welded so that it is not difficult to secure complete penetration. This is the reason a single V weld is used. The method of depositing in layers limits the heat stresses and the heat from each succeeding layer will refine the grain of the layer previously deposited. The peaning will relieve heat stress almost entirely. It will be noted that an inspection of the welding is assured while the weld is being made, and it has been our experience that with this procedure we can bring length after length of pipe to the test block, subject it to the most severe tests, hammering the weld under pressure, with the assurance that there will be no repairs to be made after the pipe leaves the test block.

The same experience has been had on other vessels which we have made. It is well worth while to spend time and effort to secure a perfect weld regardless of the specific requirement, as otherwise there will be a considerable expense due to chipping out and re-welding defective welds, and it is not conducive to peace of mind to have welding fail under shop test. With proper welding procedure and equipment welded products can be turned out consistently 100 per cent perfect. A joint can be made, and is being made, which will develop the full strength of the base metal, which will resist acids and corrosion as good or better than the base metal and which will endure under high temperatures as well as the base metal. These results are not secured through haphazard methods and can in general only be obtained by skilled supervision under laboratory control. The base metal being welded should be carefully chosen and analysis made to see that it is up to specification at all times. The weld rod to be used should be selected with care and is of immense importance. The men should be instructed as to the proper amperage to use, the proper sized rod for their work and the speed of welding, and these instructions enforced.

In the final analysis welding will not be adopted because it is cheaper than any other method of joining materials. Welding will only be used to the extent which the members of the American Weding Society desire to see it used, if it shows that it is better than any other method of joining plates.

Discussion, Committee Report on "Procedure Specifications in Welding"*

C. E. Loos†

I AM sure that all who have heard the tentative report of the committee this afternoon will appreciate the problems that this committee has before it, as its recommendations must necessarily cover the broad field to which the art of fusion welding may be successfully applied.

In their endeavor to standardize practices pertaining to the qualification of welders, supervision and inspection, they must to a certain extent incorporate some phases of the work of the other committees. I am referring to the committees directly interested in weld design and training of welders, when thinking only of the structural field.

Design for Welding

The design of welded structural steel joints depends upon a number of factors, which are influenced by the type of structure, stress distribution, cost of fabrication, ease of erection and fabrication and shipping facilities. The size and amount of welding required is determined by the unit working stresses and this figure, using a substantial factor of safety, should be based upon the average test results of a large number of welds made in accordance with the best welding practice.

I believe that the structural steel committee should furnish the industry with the proper working stresses for each particular type of joint and the work of the Welders Qualification Committee would then be limited to recommendations directed toward the production of welds of the specified strength.

Selection of Materials

The commercial medium open hearth structural steel as received from the mills is of such uniform good quality that the presence of dirt, slag, laminations or segregated carbon offers no serious problem to the fabrication of welded structural steel, but welds made where there is heavy scale and several coats of paint, such as is found on repair work, should be given consideration by the committee.

A prominent place in the committee's recommendations should be given to the proper selection and testing of suitable welding rods or filler materials. These materials play an important part in the strength and soundness of the welds and the speed of welding. These recommendations should give due consideration to the small shop without laboratory facilities for testing metallic electrodes.

*Presented at Annual Meeting, A. W. S., April 26, 1928. Committee report presented by H. H. Moss and A. M. Candy.

†American Bridge Company, Ambridge, Pa.

Supervision

Supervision starts with the training of the welders. An instructor should coach a beginner at all times during the early stages of his training, as it is as easy for the pupil to form good habits as bad ones. This early training, which is covered in the publication of the Educational Committee, is a very important link in the production of high quality welds.

The welding supervisor should by all means be a skilled welder. He should have ability to readily detect poor welds and demonstrate to the welder the proper method to follow in making a sound weld. The supervisor should, in addition, have all of the qualifications of a shop superintendent in his ability to assign each particular job to the welder who can best handle that assignment, to maintain his production schedule without sacrificing the quality of the welds and to turn out the work at a low cost.

In order to properly check the work of his welders he might require each welder to identify his work by the use of a hammer stamp similar to that used by inspectors of steel products. By this scheme failures have been traced directly to one or more careless welders. These identification marks will help to eliminate carelessness upon the part of qualified but unconscientious welders.

Again keeping in mind the small structural shop, it will be found that the supervisor must also act as a welder. In these shops devoted primarily to the fabrication of riveted steel products, fusion welding serves as an auxiliary tool, but it is just as important that these welders be trained in standard methods as the shop devoted exclusively to welding.

Inspection

Inspection is a vital question to the structural engineer who must be reasonably certain that the structure that he has designed will withstand the loads to be carried with the proper margin of safety. If he is part of the fabricating shop organization where supervisory methods are properly enforced, he can feel reasonably certain that the finished weld will meet his specifications, but the customer to whom he sells the product will also wish to check the workmanship. His inspectors must either inspect the finished product or the weld in the process of the making. In either case, to properly inspect a weld, the inspector must be familiar with the general technique of fusion welding, but it is too much to expect that he should be familiar with proper methods of design and methods for testing the completed structure. Such problems fall within the province of the designing engineer.

Under the heading of Inspection the committee should clearly illustrate the difference between welds of different strengths as indicated by their external appearance, if such a differentiation can be made.

Qualification Tests

For structural steel welding I do not believe that it is necessary to have the welder make a large number of different types of welds in order to qualify. Once he has learned the basic principles for mak-

ing a strong weld on one or two types of joints, his ability to make the different classes of welds will be directly in line with the results of his tests on the few typical joints.

The simple "V" butt weld makes a very satisfactory standard test, but requires careful preparation and attention to details. I consider the simple lap fillet weld test to be of greater importance, but with the use of these the welder's rating cannot be expressed in pounds per square inch or any other such numerical unit of strength. One of the most common problems in structural steel welding is the welding of shapes of different thicknesses and with the simple fillet weld joint, the welder's ability can readily be determined by welding pieces of scrap plate of different thicknesses together and then breaking them apart to observe the character of the workmanship. From this type of weld it can be determined whether there is proper fusion to the parent metal, whether there is the proper penetration into the corner of the weld or whether the bead has been built up to the specified throat dimension. This fracture will give an indication of the quality of the weld material, length of arc, rapidity of welding and amount of power used. If a welder can satisfy the supervisor that he can make satisfactory fillet welds with different combinations of plate thickness, he should then be permitted to make the butt weld test which will give him a numerical rating.

Welders should always be made acquainted with the results of their tests. If convenient they should be permitted to witness the tests or to be shown the broken test specimens. This practice will result in a greater effort to produce stronger welds, and if there are a number of welders the competition will be keen.

An additional simplified test is the use of an etching re-agent which may be applied by the welder to a sheared weld specimen. Such tests serve to keep the welder informed on his ability to secure good penetration without resorting to the more elaborate strength tests.

Conclusions

In concluding I would caution the committee not to overlook all of the simple and fundamental details to be observed in manual welding, for while the committee and the few directly connetced with the welding industry are thoroughly familiar with them, the structural industry as a whole may not have appreciated their real significance in helping to produce sound welds.

Simplicity should be the keynote in devising tests and making recommendations and I believe a liberal use of illustrations advisable.

I wish also to state that while the work of the Qualification Standards Committee will seem slow and tedious to them, they should feel encouraged by the thought that if they, through their recommendations, can assure the structural engineer that with proper supervision, inspection and tests, a weld of uniform physical properties can be produced at all times, the committee will have made a big step forward toward a more general use of welding in the fabrication of structural steel.

Welding in the Ford Industries*

M. L. ECKMAN†

THE tremendous public interest which concerned itself with rumors and announcements of the new Ford car and later so eagerly greeted its presentation, has finally turned to the details of manufacture. The general public now wishes to delve into the whys and wherefores.

The story is one of the wonder tales of modern industry. Mr. Ford, with characteristic keenness, saw that welding was not only the worlds best assembly method, but was the keystone on which rested the further development of the best manufacturing methods now in use and gave the word which turned his plant into the world's greatest welding laboratory, resulting in an epochal achievement.

For one hundred and fifty years the mechanical world has been taking large masses of metal such as ingots, castings and billets and learning how to form them by planing, turning, shaping and grinding, a laborious and by no means economical procedure—a new idea has been born. We will now take small parts that can be quickly and economically made from standard sheet and bar stock and build up into assemblies such as automobiles. This is logical; this is basically right. Welding makes this possible.

Welding in Production

To illustrate how welding makes use of the best in manufacturing processes note that stampings or punch press operations is one of the prime producers in manufacturing because each piece is identical, being governed by the die and not by the skill of the operator; also the number produced is governed by the pace of the machine as long as it is supplied with stock.

It is the same with forgings. Their lightness, combined with strength and speed of production, are factors that are fast causing them to supplant castings and may eventually eliminate them.

Foundries with their core making, molders, cupolas, shake out and sand reclaim, by more or less skilled men, and the related high cost of pattern making and storage; also the subsequent costly machining operations that some times removes as much as 30 per cent of the original weight in getting them into finished parts, can never compete with forgings, where, by one squeeze in a forging press the heated metal is formed into a part which can be duplicated at every revolution of the press. All pieces having a minimum pre-determined amount of machining stock.

Welding makes possible the uniting of forgings and stampings into

*Presented at Annual Meeting, A. W. S., April 27, 1928.

†Welding supervisor, Ford Motor Company.

integral parts of strength, lightness and symmetry at a speed unequaled by any known process. A motor car in which no castings are used, except in the power plant, is the result; also economies in material and weight, by eliminating the over lap of parts where joined together as in previous designs, are notable accomplishments.

Come with me into the production shop, one minute. You hold in your hand two separate pieces, one a forging and the other a stamping. Here they are clamped into a peculiarly designed machine; there is a flash, a shower of sparks, and the next instant you are handed the

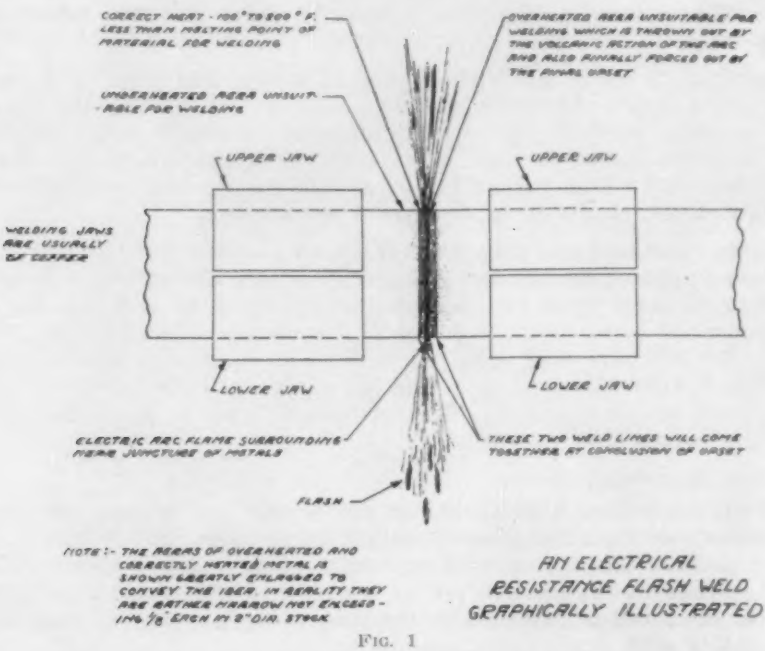

CORRECT HEAT - 100° TO 200° F. LESS THAN MELTING POINT OF MATERIAL FOR WELDING
OVERHEATED AREA UNSUITABLE FOR WELDING WHICH IS THROWN OUT BY THE VOLCANIC ACTION OF THE ARC AND ALSO FINALLY FORCED OUT BY THE FINAL UPSET
UNDERHEATED AREA UNSUITABLE FOR WELDING
UPPER JAW
UPPER JAW
WELDING JAWS ARE USUALLY OF COPPER
LOWER JAW
LOWER JAW
ELECTRIC ARC FLAME SURROUNDING HERE JUNCTURE OF METALS
THESE TWO WELD LINES WILL COME TOGETHER AT CONCLUSION OF UPSET
FLASH
NOTE:- THE AREAS OF OVERHEATED AND CORRECTLY HEATED METAL IS SHOWN GREATLY ENLARGED TO CONVEY THE IDEA. IN REALITY THEY ARE RATHER NARROW NOT EXCEEDING 1/8" EACH IN 2" O.D. STOCK
AN ELECTRICAL RESISTANCE FLASH WELD GRAPHICALLY ILLUSTRATED

FIG. 1

parts which have become *one* permanently, before your eyes in less than half a minute. This smacks of witchery, and it is—The Aladdin's Lamp of production methods.

Flash Welding

I wish to call your attention to that particular class of welding generally known as resistance welding and subdivided in the order of their importance into flash welding, spot welding and seam welding. In order that no misunderstanding exist, let it be known that I am going to confine the most of my talk to that particular class known as Electrical Resistance Flash Welding, which has proved conclusively to be the premier of all welding methods for production or repetitive purposes.

To correct the erroneous idea that this is something mysterious, I submit the following illustration, Fig. 1, and text, Fusion Welding is

essentially a casting, but in the flash weld no metal is added, the original metal only is used and in heating has been fully protected from the oxygen in the air and other impurities. The upsetting improves the metal by refining the grain.

There is no difference between the theory of the old fashioned blacksmith weld and the electrical resistance flash weld, although there is a marked difference in favor of the resistance flash weld practically.

Blacksmith Weld

The blacksmith put his steel in a forge and the heat was applied externally, the steel often absorbing impurities from the heating medium. When at the proper heat it was removed, the surfaces to be

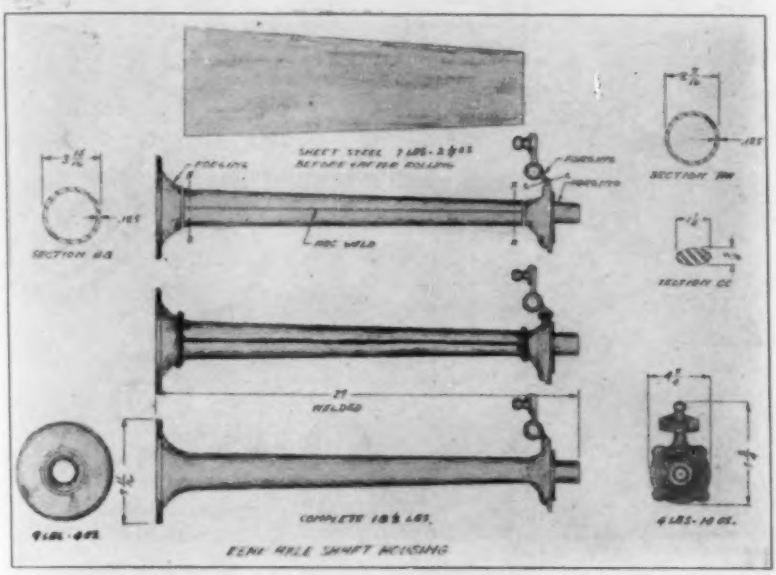


Fig. 2. Rear Axle Shaft Housing

joined were cleaned of oxide and placed together and hammered vigorously.

The actual welding was accomplished by heat plus pressure.

Electrical Resistance Flash Weld

In resistance flash welding the heat comes from an arc drawn between the surfaces to be welded. As it will not heat sufficiently to weld except through the heat of the arc between the surfaces, it is necessary to have the pieces of a uniform cross sectional area or nearly so.

Copper jaws conduct the current to the piece to be welded and control the heat at the weld. Therefore, their distance from the weld should be uniform in all directions and on each piece. The amount of flashing is determined by experience and if right, has produced

zones in the pieces to be joined that have been protected from the oxygen and other impurities in the air by the arc and have been heated from the inside out speedily to correct welding temperature. Now comes the forcing or squeezing of the two pieces together very quickly with no loss of time to remove from the heating medium by the application of the lever and fulcrum principal in a toggle action of enormous power much better and quicker than it could be hammered together. This squeezing also forces out any overheated metal that may be left, allowing the good, clean virgin metal to make contact.

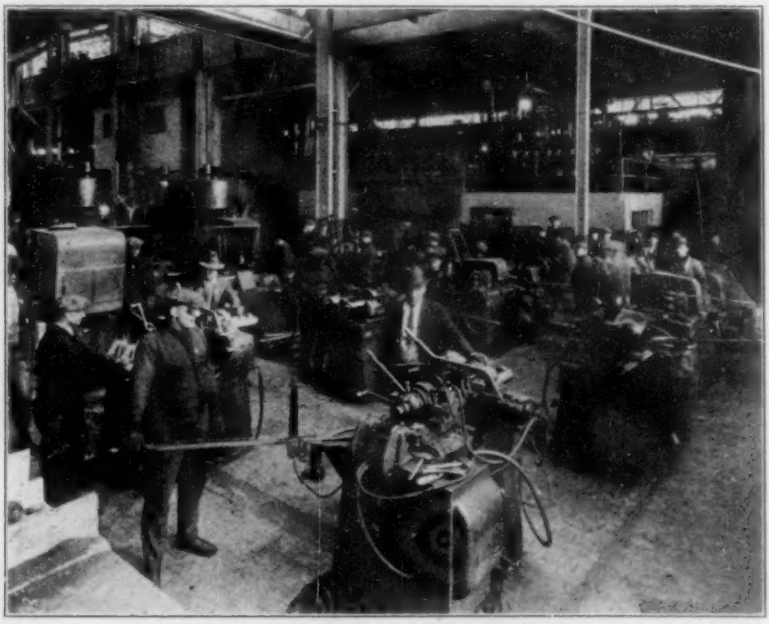


FIG. 3. GENERAL VIEW OF WELDERS IN ACTION ON ASSEMBLY OF AXLE SHAFT HOUSING

This welding reduced to essentials is just heat plus pressure.

Let us make a study of the Model "A" Ford car by this assembly method, starting with the running gear and chassis.

Rear Axle Shaft Housing Assembly

Fig. 2 shows in detail the four individual parts that are welded into one integral unit shown at the bottom whose entire weight is only 18½ lb. The small spring Perch is a steel forging, machined accurately and the ball for the shock absorber hardened. They are placed in a Ford designed welder and flash welded together at the rate of 150 per hour. Area of weld 0.75 sq. in. The burr, or in welding nomenclature, the "Flash," is removed from the juncture in a special machine and it is ready for the next operation of welding to the tube, which is done at the rate of 100 per hour. Area 1 in—weight 5 lb. 4 oz.

The tube is a piece of 0.125-in. x 20⅝-in. sheet steel weighing 7 lb.

4 oz. that is blanked successively in wedge shaped form from a large steel sheet, formed in three operations on a punch press, then arc welded longitudinally at the rate of 50 per hour. It is then restruck to insure uniformity of size and shape and is ready to flash weld to the bell end forgings at the rate of 60 per hour. Area 1.50 sq. in. Weight 7 lb. 13 oz.

This bell end forging is an unusual development by Ford engineers and is made by hot rolling or spinning a blank of hot steel between two

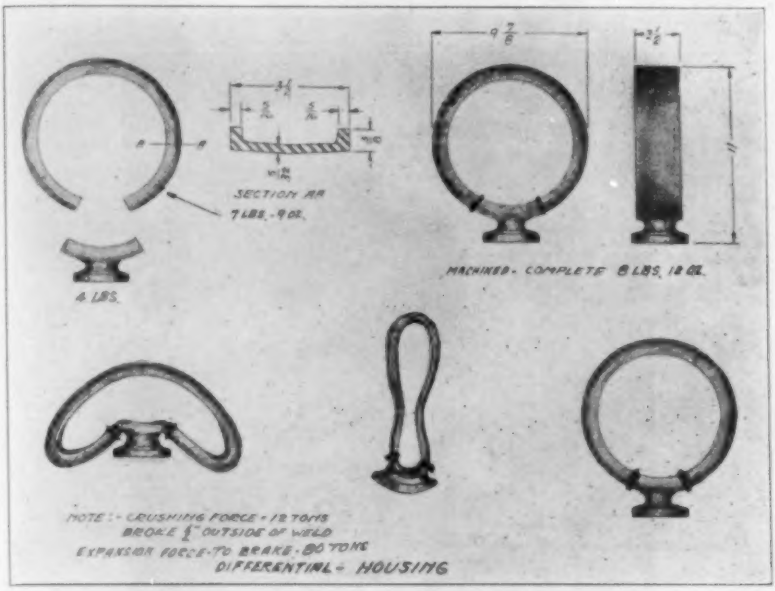

SECTION AA
7 LBS. - 9 OZ.
4 LBS.
MACHINED - COMPLETE 8 LBS. 12 OZ.
NOTE:- CRUSHING FORCE - 12 TONS
BROKE ½" OUTSIDE OF WELD
EXPANSION FORCE-TO BRAKE-80 TONS
DIFFERENTIAL - HOUSING

FIG. 4

formed rolls at enormous pressure and high speed. The procedure forming a graceful curved bell uniform in thickness at no sacrifice of strength.

The four pieces have now become one through welding, each is machined in line with the other and will always maintain that alignment and rigidity as continuity of shape and line makes for great strength as well as beauty. In this design there is no overlap of one piece on another and therefore no piece to shift or move in process, assembly or use. There are two of these per car, identical in every way except in the position of assembly in regards radius rods, etc.

On test these housings have withstood 25 tons tortional strains with no failures. Tested to destruction the tube collapses at 50 tons with no failure of the weld. Tested for fatigue, with the bell end clamped solid and the other end oscillated ¼ in. eccentric at 250 r.p.m., it failed in 167¼ hours. Total oscillations 2,508,745 failure occurred outside the weld.

Fig. 3, shows a bird's-eye view of the welders in action on this assembly. Note that all machines are of special design and I assure you that if there are any tricks in this trade it is in the conception, development and working out of these machines.

Differential Housing Assembly (*See Fig.* 4)

Here a casting has been eliminated in favor of the all-steel housing made possible by welding. A channel section as shown is rolled in our mills and formed circular in four punch press operations. To it is flash welded a neck forging made in three operations on an Ajax

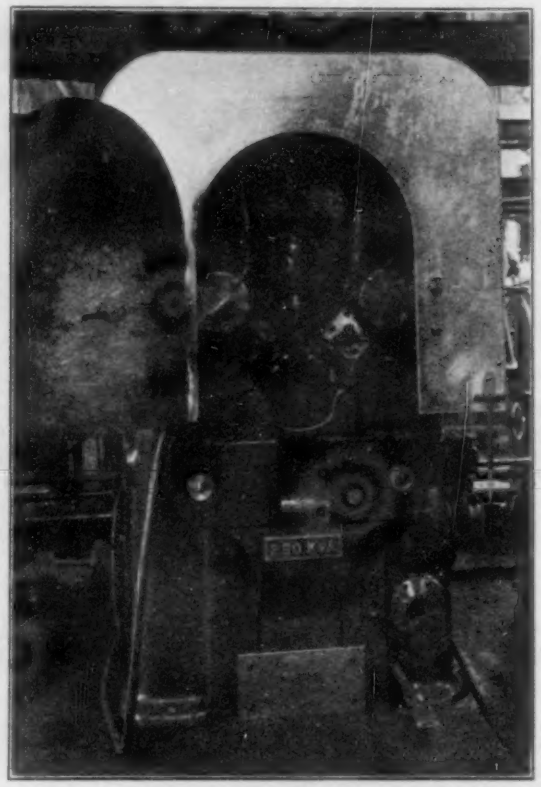


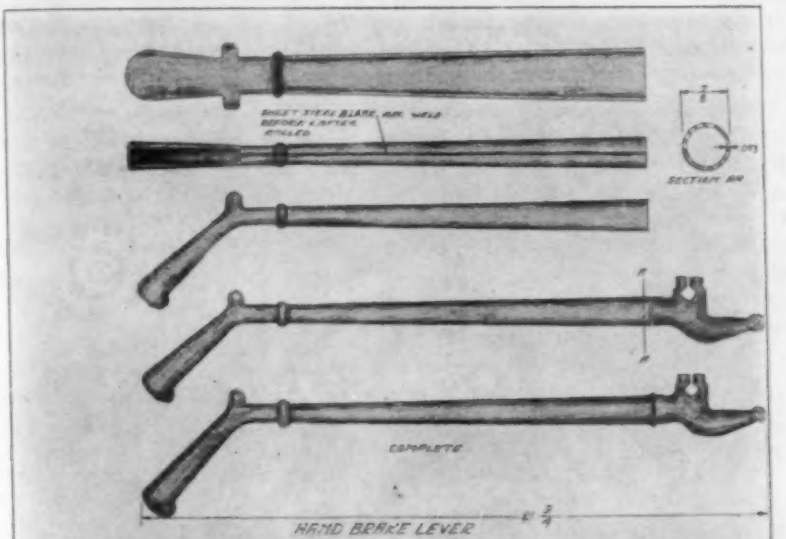
Fig. 5. Automatic Machine for Differential Housing Assembly

forging machine, rough machined prior to welding. A description of the original machine operations compared with the automatic type just developed will show how welding engineering along this line is advancing.

The channel ring is placed in its cradle and aligned; the removable clamps are dropped into place and a valve is turned which releases the air into two cylinders which in turn actuate the clamps and pull the

ring against the electrodes on either side. The operating handle is pushed back from the loading position to the open or starting position. The neck is slipped over the expanding collet, which is also the electrode, against a locator and aligned. The forked clamp is slipped into place and the air is turned on expanding the collet. Actual welding procedure now starts. The operator grips the handle and throws the trigger switch, turning on the current. He burns off the abutting ends of the neck and ring to get a good even contact. Then for three

FIG. 6. HAND BRAKE LEVER



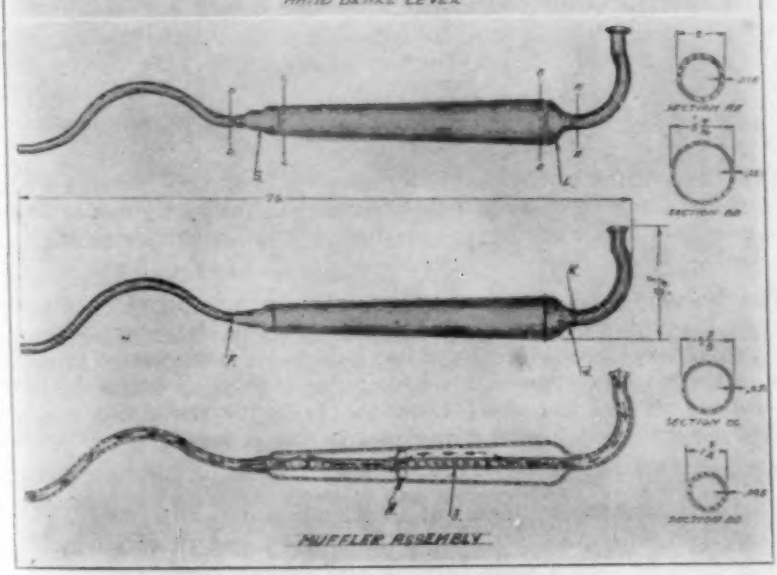


FIG. 7. MUFFLER ASSEMBLY

or four seconds the ends are held tightly together and preheated. The arc is then drawn between the parts by backing off the handle enough so that the current leaps the gap, drawing an arc whose heat is estimated at 10,000 Fahr. The operating handle is now brought up evenly and steadily, to maintain this arc to a predetermined point, the correct heat being the determining factor, at which time it is pulled home as quickly and vigorously as two husky fellows can manage. (This same procedure, while simple to explain, takes careful training to accomplish correctly and has been one of the hardest problems to work out in an automatic machine.) The air is then released, the clamps removed, the operating handle is pushed back to the open position and the housing lifted out completely welded. Three operators are necessary for each machine, production 25 to 30 per hour.

This machine, now on production, welds on the same principal except that the two ring clamps are part of the machine and the operator's duties consist of placing the stock in the machine, slipping the U-shaped clamp on the collet end and turning the air valve which clamps all parts at once. The machine is then tripped and goes through the welding cycle automatically to completion. The air valve is opened and the machine returns to its starting position where the housing is removed and the operation repeated. (Fig. 5.)

The improvements in this automatic machine are:

1.—Two men eliminated—one operator runs the machine.

2—100 per cent increase in production; 50 to 60 pieces per hour.

3—Less floor space occupied per unit—75 per cent of the original machine.

4—Welding more uniform as the human element has been removed from the actual welding cycle.

This housing weighs 8 lb. 12 oz., area of weld 2 1/16 sq. in., the largest production weld in operation at this time, although much heavier are being developed. Extremely heavy welds have been made on non-productive work which I will take up later. This housing crushes at 12 tons and fractures at 80 tons expansive force all fractures occurring outside of weld.

This description of the actual welding cycle on this housing by hand is identical for most manual welded parts. Usually only one or at most, two operators to a machine, production on smaller parts running to 200 per hour.

The full type automatic machine is claiming our close attention. All machines in the future will incline to this type, on account of uniformity and speed. Mr. Ford has held to his progressive production idea in the manufacture of this housing as it moves progressively from the rolling of the hot steel from the billet to the finish machined article not having traveled many feet in the process.

Differential Ring Gear and Other Parts

Steel is rolled in our mill, cut to length and formed into a ring in the ajax machine, flash welded and machined and the teeth produced. This is cheaper then a solid forging and just as good.

The drive shaft housing consists of a tube to which is flash welded a flanged forging on the differential end and a ball forging on the transmission end. These being finish machined in line after welding insure permanent alignment and rigidity.

The two rear radius rods have terminal forgings flash welded to each end. The front radius rod has a front terminal forging flash welded to the front end and a yoke forging to the rear. The irregular shaped tube being blanked, formed and arc welded longitudinally.

The equalizer brake shaft consists of two forgings welded to the ends of a bar, right and left. The brake and clutch pedal foot pads are welded to the forgings proper. The four brake rods are welded to the terminal forgings.

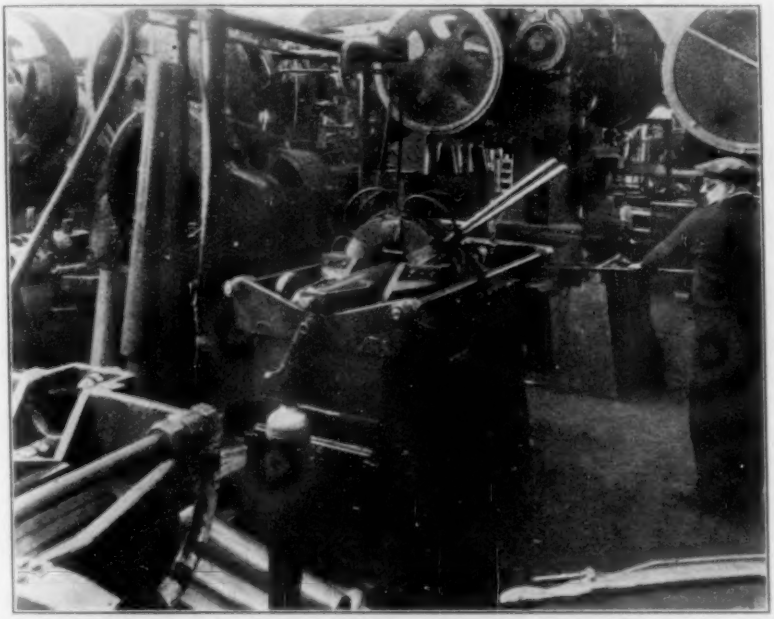


FIG. 8. MUFFLER WELDER IN ACTION

Hand Brake Lever (*Fig.* 6)

This is made from a stamping, blanked and formed and arc welded longitudinally, then flash welded to a terminal forging. The pawl rod concealed inside the hollow handle is a big improvement over the conventional design with the pawl rod outside. Weight 1¼ lb.

Muffler Assembly (*Fig.* 7)

This is an ideal example of the punch press welded form of production assembly. An outer shell of sheet steel 0.037 in. thick is blanked from a sheet formed into a taper tube and spot welded. The center baffle shown at "A" is spot welded into place. The large bell end

blanked and formed in a punch press is flash welded into the large end of the outer shell. See "L" the small bell end; see "S" blanked and formed is then welded to the small end of the tube. The center shell, in which is spot welded two baffles, is next assembled through the small bell end center baffle and spot welded to the small end of the large bell end at "J." The rear end of the center shell is left free to expanded with the heat of the exhaust gases. The inlet pipe is flash welded to the center shell and large bell end at "K." The outlet pipe

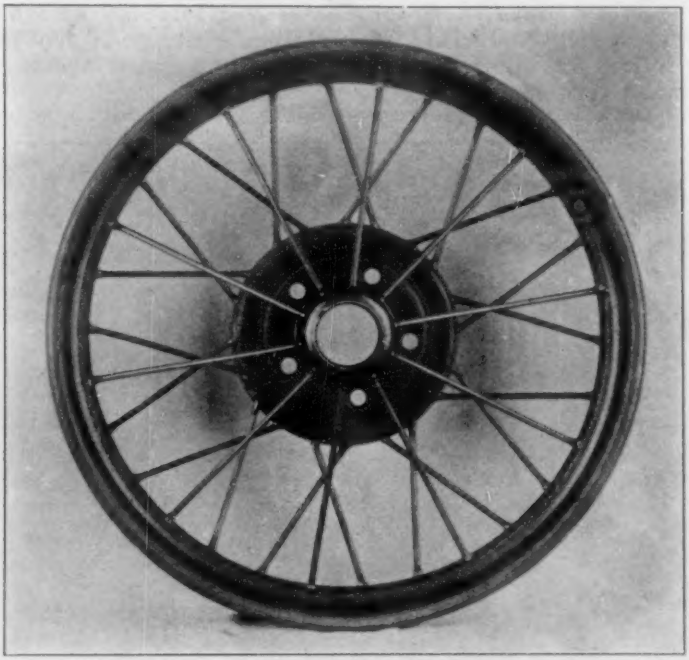


FIG. 9. ALL WELDED STEEL WHEEL

is flash welded to the small bell end "F" and this completes the muffler. Actual operation takes less time than it takes to describe it. This muffler being one piece does not ring and efficiently deadens the explosive force with a minimum of back pressure. Note the arrows show the path of the exhaust gases. Weight 12 lb. 7 oz. Fig. 8 shows muffler welder in action.

The spare wheel carrier is a piece of tubing flash welded to two pressed steel flanges. The bumper cross bar is a tube welded to two flanges.

Wheels

The Ford designed all-steel wheel is undoubtedly one of the finest wheels ever designed. Forty attempts to break this wheel by skidding it against the curb side ways succeeded in bending some spokes, but did not injure the wheel enough to make driving impossible. Rail-

road locomotives have hit these wheels without the welds failing, although the wheel was ruined. Five wire wheels complete, weight 36 lb., less than four wooden wheels and a spare rim, and most of the weight is removed from the periphery of the wheel where its inertia is of maximum undesirability. (See Figs. 9 and 10.)

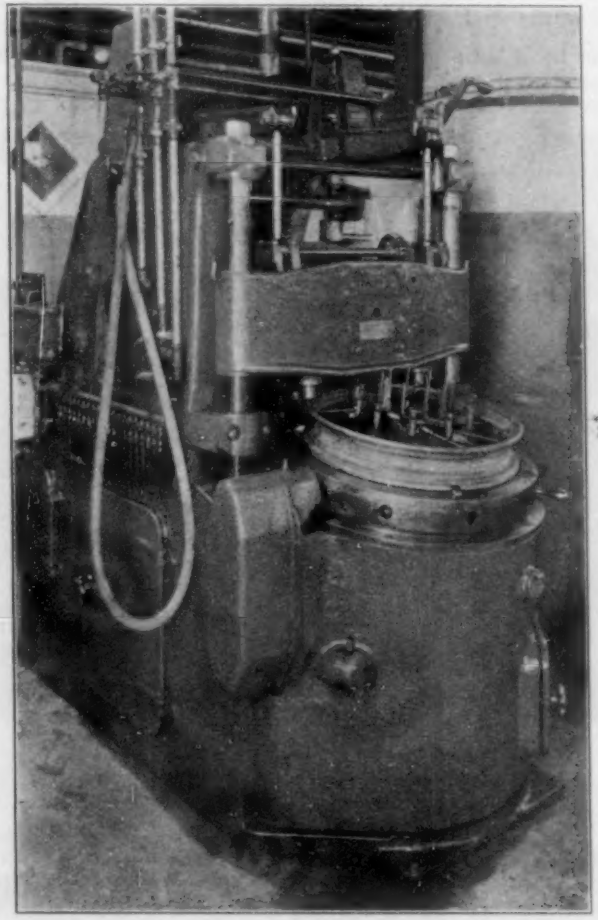


FIG. 10. WELDING ALL STEEL WHEEL

The hub shell is blanked and formed in seven operations on a punch press. The rim is a strip of steel formed into a circle and flash welded together. It is then rolled formed and embossed.

The spokes are cut off, upset and cupped on a cold heading machine direct from the coil of steel wire.

The rim is placed in a special welder and 10 short spokes of the same angle are welded in place, one at a time, the machine indexing and welding automatically.

The ten short spokes of the opposite angle are welded in another machine of similar design. Next the hub shell is assembled and welded to the spokes in two separate operations. The long spokes are next welded to the outer rim and then welded to the hub shell, six welding operations in all of ten welds each, thirty spokes complete this trinity of hub, spokes and rim. I call your attention to the triangular bracing of these spokes.

The front head lamp brackets and fender brace are of tubing welded to forgings on either end.

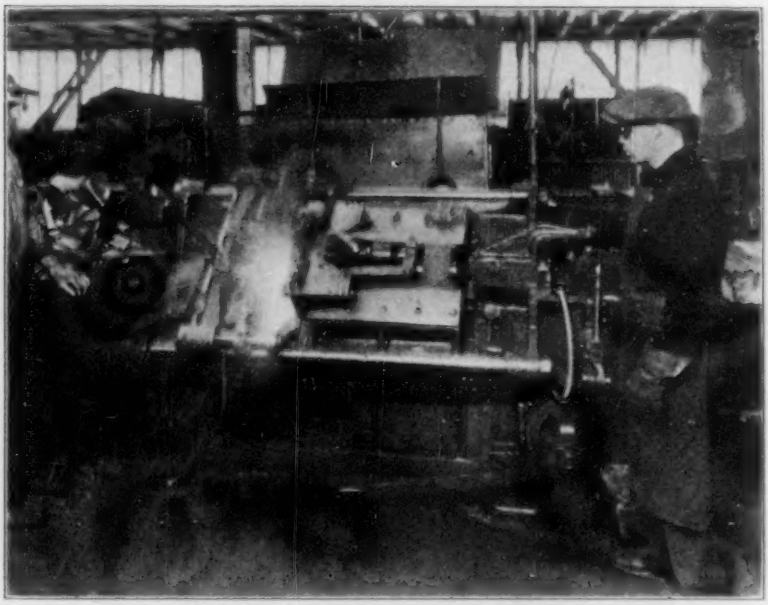


FIG. 11. BATTERY SUPPORT WELDER

Battery Support Assembly

This is made of a piece of strap steel formed in a punch press and flash welded to two terminal forgings at once. The webbed bottom plate is next located in a corresponding web and spot welded in place. This battery box support is strong enough to lift the car, but it is very cheaply and quickly made by welding. Fig. 11 illustrates the Battery Support welder.

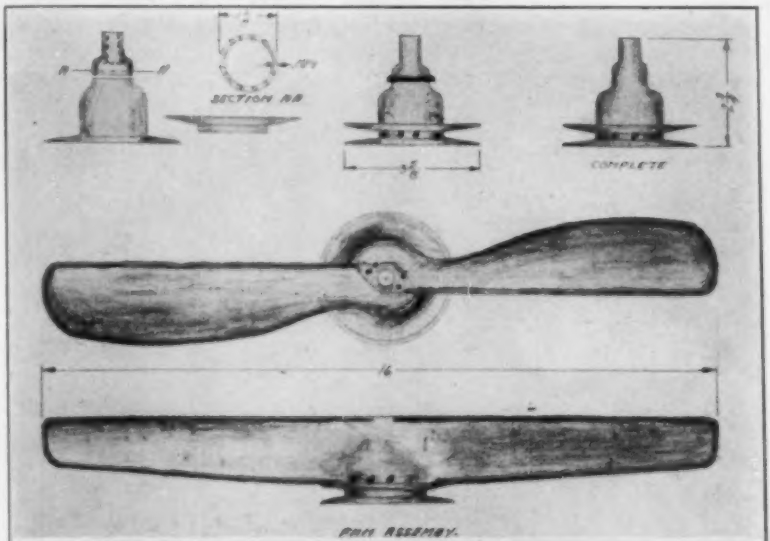
Steering Gear, etc.

The steering gear is a forging made in two halves and arc welded together and then flash welded to the tube. Again a trinity of parts.

The front brake shaft housing is sheet metal formed into a tube and arc welded longitudinally and then flash welded to a terminal forging on either end. Two per car.

The starting motor shaft is made in two pieces and flash welded. The steering gear connecting rod is arc welded. The engine oil pan baffles and clamp reinforcements are spot welded. The outside clutch plate and washer are assembled by spot welding. The brake shoes are welded by the projection method. One hundred and twenty-eight welds per car.

FIG. 12. FAN ASSEMBLY



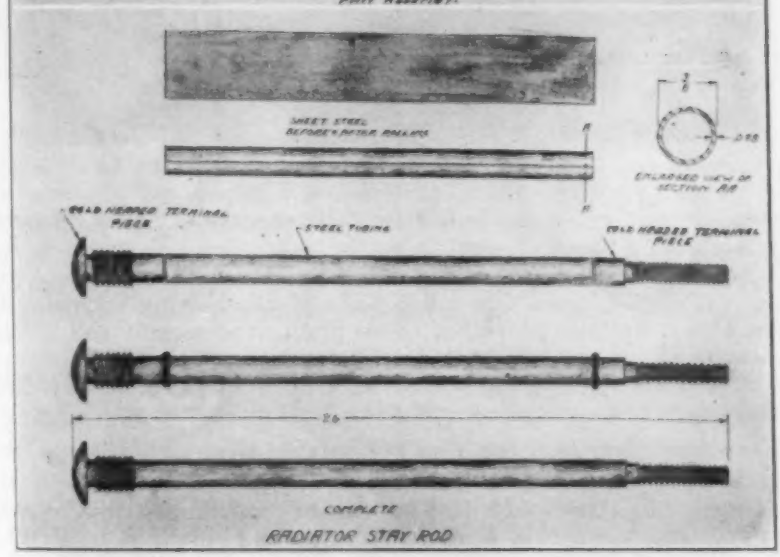


FIG. 13. RADIATOR STAY ROD

The rear operating brake wedges are projection welded. The main bearing oil pipe is arc welded. The oil pump body is welded.

With one or two exceptions this completes the welding on the chassis proper.

Fan Assembly (*See Fig.* 12)

This might be called a precision welding development. The hub of the pulley is made on an automatic screw machine and the pulley body is a stamping. They are flash welded together in a Ford machine of unique design and conception, the maximum allowable misalignment

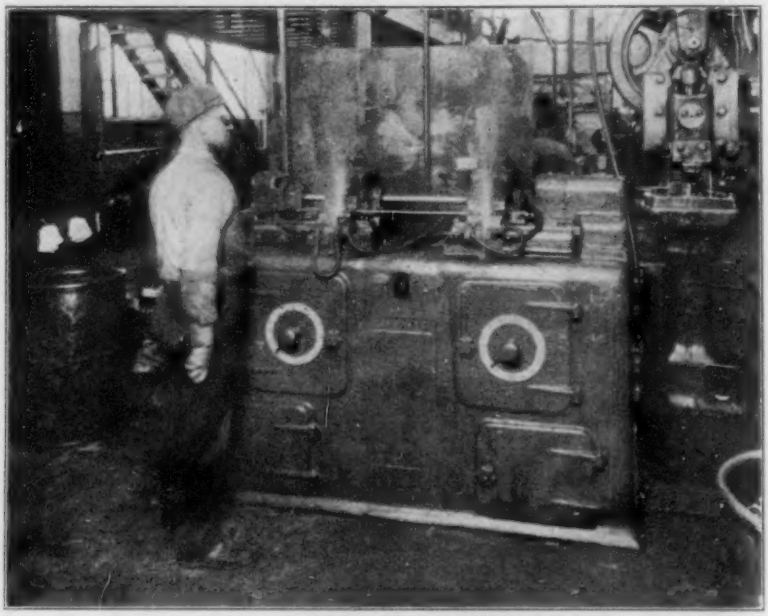


FIG. 14. SEAT REST TUBE ASSEMBLY

is 0.0025 in., and it is indicated at a distance from the weld so the tolerance at the point of weld is really less. The hub flange is next spot welded to the pulley. The fan is clamped in place and spot welded. The fan in itself is a fine piece of engineering following the design of an airplane propeller whose pitch, lead weight and balance are figured accurately. It is made of two pieces of sheet steel formed in a punch press and seam welded on a machine designed especially for this operation. One man producing 150 fans per hour.

Radiator Stay Rod (*Fig.* 13)

This is made from a piece of sheet metal 0.038 in. x 1¼ in. x 23⅝ in., formed into a tube and flash welded to two terminal pieces made from steel wire on a cold heading machine and threaded in a thread roller, 2500 in 8 hours by one man. Ford design special built machine. Weight 6 oz.

Fig. 14 illustrates seat, rest, and tube assembly. So you see light material can be welded as well as heavy.

Door and Frames

The closed model door is made in four parts on a punch press and flash welded together into one piece, probably the strongest door for its size and weight in existence. The entire door is assembled by welding, this includes bumper plates, belt panels, window runs, outer shells, etc.

FIG. 15. WELDING THE FUEL TANK

The windshield frame, the rear window frame and side window frame are all flash welded together in their respective assemblies. The foot accelerator is a forging flash welded to a rod.

In general, welded design makes for strength, speed and lightness combined with beauty, and the possibilities of this method of production have not been exhausted; in fact, the surface has only been scratched.

Fuel Tank

The fuel tank is one of the vital parts of the car that has been intrusted to welding. The elimination of a cowl, an instrument board, a vacuum tank system in favor of a two-piece simple type of fuel tank that is all of these and more, with the increase of safety and economy, are factors that every car user should note. This tank is made from terne plate or lead coated steel as a preventive of rust. Three years were spent solely in developing the methods of manufacture and

welding, and it was a heart-breaking task to develop this welding. No machines in existence would do this job as desired at the start so machines were redesigned and again redesigned, but finally success came.

I have seen tanks dropped off the factory buildings filled with water, 90 lb. per square inch air pressure turned in to them, cars going 60 miles per hour wrecked with no failure of the weld. All tanks in our inspection undergo two tests with compressed air submerged in water before they are passed. They are welded by being passed between copper electrode rolls at the rate of 40 in. per minute, the upper roll being driven and the lower one an idler. As it advances there is a surge of electric current at regularly stated intervals. This carefully regulated current which, of course, generates the heat, combined with pressure does the welding. That this is no sinecure, let me state, that all the following conditions must be carefully guarded to keep quality. (Fig. 15.)

1—Uneven, irregular or dirty stock.
2—Bearing conditions.
3—Primary current fluctuations.
4—Pressure width and condition of rolls.
5—Speed and condition of interrupters.
6—Cooling system.
7—Welding speeds.
8—Care in operating.

Personnel

The welding development at the Ford plant is under the superintendent's office and the personnel is composed of trained engineers and mechanics, always alert to the possibilities of advancement in welding technique and welding equipment design.

There are some 700 men employed in design, building, training and supervising welding activities.

Some 1500 men are engaged as machine operators on welding machines and are not considered as welders, but production men, whom we supervised as far as welding is concerned.

Equipment

The Ford Motor Company believes in welding. There are 140 arc welding machines in operation, the majority in non-productive work. Over 200 skilled arc welding operators, automatic operators not being considered skilled. There are 318 skilled acetylene welders employed. There are 320 special designed flash welding machines, 540 special designed spot welding machines, and twenty-five seam welders designed to specifications. At present there are 200,000 flash welds made per day of 24 hours, and in round figures 3,000,000 spot and projection welds.

Equipment

Do you wonder that the Ford motor plant is the world's largest welding laboratory? We believe that we have made further strides in the last five years than in the previous twenty-five and the last two have

been very productive. Many machines had to be conceived, designed and built that were radical departures from any in existence. Fixtures had to be developed and ways and means found for doing the unheard of.

Truly welding is the small boy of the metal industries grown over night into strong and vigorous manhood. Like all prodigies he inspires no little awe. But who can long withstand the strength, lightness and symmetry of welded design.

Tests on Flash Welded Material

A reprint of communication sent to the superintendent's office Sept. 23, 1926:

Gentlemen:

Herewith is a cross section of the largest flash weld ever made in our welding shop and probably in the world. Eight-inch solid stock. Machine steel, guaranteed 60,000 lb. tensile strength.

One section is ground, polished and etched in acid. Etching shows a perfect weld. The welded zone being indicated by the finer crystallization of the metal.

The other section was machined into a standard test bar and pulled to destruction. Fracture occurred $\frac{5}{8}$ in. from the weld zone. Test is ground to size plus or minus .0001 in. of an inch.

Size	Steel	Tensile Strength	Elastic Limit	Elongation in 2 In.	Reduction of Area	Remarks
Test Bar	M.S.	62,750	39,500	32.8%	66%	
Other tests.						
Test Bar	M.S.	58,500	36,900	34.7%	65%	
Test Bar	M.S.	60,000	39,000	35.0%	67%	
Test Bar	M.S.	60,000	38,000	35.0%	66%	Not Welded
Test Bar	T.S.	112,000				
Test Bar	T.S.	110,000				
Test Bar	T.S.	118,000				Not Welded
Test Bar	H.S.S.	104,000				
Test Bar	H.S.S.	123,000				
Test Bar	H.S.S.	115,000				Not Welded
Test Bar	A.Van.	75,000				
Test Bar	A.Van.	76,000				
Test Bar	A.Van	80,000				Not Welded
Test Bar	AAA.Van.	96,000				
Test Bar	AAA.Van.	95,000				
Test Bar	AAA.Van.	100,000				Not Welded

Analysis	Carbon	Manganese	Chromium		Sil.	Phos.	Sul.
M.S.	.08–.20	.35–.50			.15	.04	.05
T.S.	.35–.40	.70–.90			.10	.03	.05
H.S.S.	.60–.70	.25–.35	3.75–4.25	Vanadium .90–1.10	.25	.03	.04
A.Van	.17–.22	.60–.75	.65–.80	Tungs. .17–.18 Vanadium .12–.16	.15	.03	.04
AAA.Van.	.30–.35	.65–.80	.90–1.10		.20	.03	.04

FLASH WELD TESTS ON STRUCTURAL STEEL

Size	Shape	Actual Pull	Remarks
2 in.	Channel	42,200	Broke outside of weld.
2 in.	Channel	41,500	Not welded.
3 in.	Channel	83,900	Broke outside of weld.
3 in.	Channel	78,000	Not welded.
3 in.	I-Beam	93,500	Broke outside of weld.
3 in.	I-Beam	90,900	Broke outside of weld.
3 in.	I-Beam	93,600	Not welded.
18 in.	I-Beam	.....	58,200 lb. per sq. in. tensile strength. (Broke outside of weld.)
Transverse Tests			
44 in.	I-Beam	20,900	Broke outside of weld.
4 in.	I-Beam	20,600	Not welded.
6 in.	I-Beam	37,200	Broke outside of weld.
6 in.	I-Beam	35,300	Not welded.
8 in.	I-Beam	59,600	Broke outside weld.
8 in.	I-Beam	54,800	Not welded.
10 in.	I-Beam	79,800	Broke outside of weld.
10 in.	I-Beam	84,500	Not welded.

800 miles of pipe of all sizes from 1 in. to 6 in. have been salvaged by flash welding methods from the 200 boats Mr. Ford bought from the Government.

Accurate data as to speeds and cost of flash welding are a little hard to give as every job presents different problems, size and shape being the chief factors.

However 1 in. area of steel may be welded in 5 seconds at a cost of $0.0018.
2 in. area of steel may be welded in 11 seconds at a cost of $0.004.
(In our production department we better these figures in almost every case.)

The problems met and mastered, the results obtained show that Mr. Ford's foresight has produced an entirely new manufacturing process that is revolutionary in character.

Welding Corrosion Resisting Steel Alloys*

W. B. MILLER†

THE use of high chromium alloys as engineering materials to withstand corrosion, and oxidation at high temperatures, is increasing rapidly. As may be expected there is an insistent demand for information concerning the welding of these alloys, since they present difficulties not encountered in the welding of ordinary low carbon steel. The high chromium steels designed to resist various forms of corrosion are known under a large variety of trade names. Each name may apply to a group of alloys in which one or more elements vary according to the specific properties desired. The element chromium is the most important of the corrosion resisting group. The other constituents such as nickel, silicon, manganese and carbon play an important part in this class of alloys especially with regard to the welding problem. No attempt will be made to classify the alloys according to their trade names as such classification would require needless repetition and would be confusing. A brief description will be given of the more common groups according to their composition and more generally accepted group names. The welding procedure for a given group will therefore be much the same regardless of the slight variations in chemical composition which may occur within it.

Rustless iron is considered here as that group of alloys containning between 12 per cent and 20 per cent chromium with less than .15 per cent carbon, the remainder being iron with normal amounts of manganese and silicon. Within this composition range there are two classes of alloys which are commercially available, the class being determined by the chromium content. The alloys containing 12-14 per cent chromium constitute one type and those with 14-20 per cent chromium the other type. The resistance to corrosion increases with increasing chromium content.

Stainless steel belongs to the group containing 12-14 per cent chromium with upwards of .2 per cent carbon. The difference between rustless iron and stainless steel lies in the carbon content. Stainless steel is very susceptible to heat treatment, its corrosion resistance depending on its heat treatment and surface finish. On account of the air-hardening properties of the alloy, welds and metal adjacent to the weld in stainless steel will be hard and brittle. This brittle condition may be remedied somewhat by annealing followed by slow cooling. After this treatment the metal will not have its maximum stainless properties which are developed only by quenching and drawing operations followed by proper surface finishing. On account of the hardness and brittleness of welds in stainless steel and the difficulty of properly heat treating and surface finishing the material after welding, stain-

*Presented at Annual Meeting, A. W. S., April 26, 1928.

†Union Carbide & Carbon Research Laboratories, Long Island City, N. Y.

less steel is unsuitable for welded parts subjected to corrosion, stress or vibration, unless the stress is taken up by adjoining parts.

The addition of nickel to rustless iron produces another class of alloys, the nickel having a marked effect on the physical properties of the metal. Alloys containing 8-25 per cent chromium and 7-22 per cent nickel are characterized by a combination of physical and corrosion resisting properties rendering them particularly suitable for welded construction, since welds and metal adjacent to the weld in these alloys

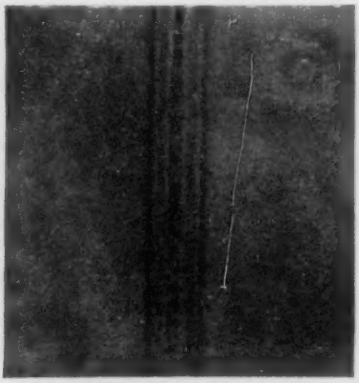


FIG. 1. WELD IN HIGH-CHROME STEEL

are ductile and require no subsequent heat treatment. The choice of any composition will depend on the corrosion conditions encountered. All alloys in this class are austenitic, easily welded, and yield welds having good strength and ductility. About 1 per cent each of manganese and silicon improves the welding quality.

All aforementioned groups are commercially available in the form of rolled or forged shapes. Seamless tubing is now available in all classes except the stainless steel. Welded tubing made from strip or sheet may also be obtained, especially in sizes under 3 in. in diameter. Approximately the same procedure may be followed in welding all classes of alloys, herein described, by the oxy-acetylene method; the chief difference lies in the after treatment. It is practically necessary to use the oxy-acetylene method of welding for the light gages; and in the discussion to follow, it is assumed that the material is in sheet form of 16-gage or lighter. It is desirable, where possible, to flange the edges which are to be welded. Butt welding without flanging the edges is permissible with sheet 16-gage or heavier. A flange about 1/6 in. wide will furnish the requisite amount of material for melting down, thus eliminating the use of a filler rod. For filling small holes or reinforcing the weld, rods of the same composition as the sheet should be used. It is advisable to clean the scale from the edges to be joined and they should be painted or coated with a special flux developed for this class of work. This flux is now on the market under the trade name of "Cromaloy Flux." It is necessary to use this flux to obtain

good results. By painting the flux along the bottom of the seam to be welded, air is excluded from the seam by the molten flux and perfect bottom fusion is obtained. Without the use of the flux oxidation, due to the heating, takes place rapidly, preventing good fusion at the bottom of the seam. Chromium oxide is infusible and prevents the metal from flowing together. Wherever possible pickled material should be used, as this insures a surface free from objectionable oxide. With the use of the flux, single vee welds in material ⅛ in. thick or heavier can be made having perfect fusion at the bottom of the seam, using

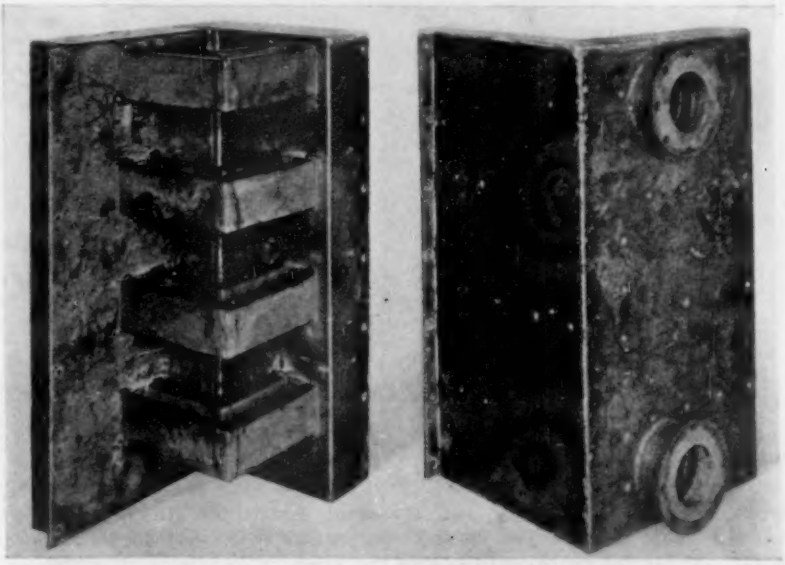


FIG. 2. WELDED RECUPERATOR OF HIGH-CHROME STEEL BEFORE ASSEMBLY

rods of the same composition as base metal. While it is true that welds can be made in some of the alloys without the use of flux, much better welds will be obtained through its use.

A neutral oxy-acetylene flame should be maintained during the welding operation. An excess of acetylene should be avoided as it will cause an appreciable increase in the carbon content of the weld, increasing the hardness and lowering the ductility of the weld metal. An increase in carbon will also lower the resistance of the weld metal to corrosion. This is particularly true with the lower chromium alloys. With an excess of oxygen a refractory slag is formed resulting in poor quality welds. Welding should be accomplished with a flame just large enough to secure satisfactory fusion, since a large excess of heat causes the metal to boil resulting in porous welds.

Rustless iron has a tendency to be brittle in the weld metal and in that portion of the base metal adjacent to the weld as a result of the high temperature attained during welding. Rustless irons, particularly

the 12-14 per cent chromium grade, are subject to air hardening and require annealing to restore toughness to the weld metal and base metal adjacent to the weld. Proper subsequent heat treatment will remedy the brittleness to a large extent. However, it is not always possible to apply a heat treatment because of size or other features of construction. The best results are obtained by heating the welds to 650-750 deg. C. for ½ hour and cooling slowly, though air cooling will in some cases answer the purpose. The welding torch may be utilized

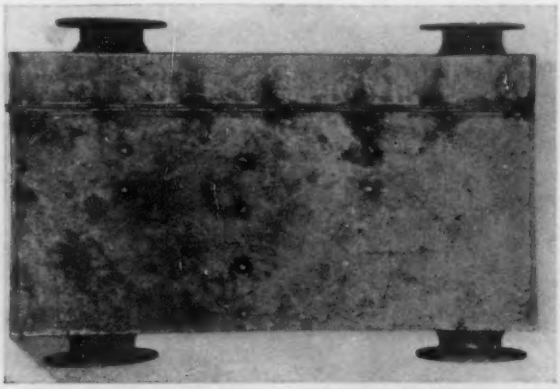


FIG. 3, RECUPERATOR ASSEMBLED

where it is not possible to employ furnaces, though the results are not so good. When using the torch for annealing, great care must be exercised to avoid heating the material above 800 deg. C., to avoid hardening the metal. The benefit to be derived from torch annealing will depend on the temperature and the time of heating. Usually about five minutes within the above temperature range will appreciably soften the metal affected by the welding heat.

Rustless irons which contain appreciable amounts of nickel are not subject to this brittleness and are quite ductile in the "as welded" condition. These alloys are austenitic under all conditions of heat treatment, consequently they do not harden, so that weld metal cooled either rapidly or slowly is malleable and ductile and requires no heat treatment. However, the tensile strength and ductility are enhanced by a water quench from 1050 deg. C. On account of distortion this drastic treatment can be applied to only a few welded products.

In order to show what results may be obtained with welds in the various types of alloys discussed, three compositions in the form of 18-gage sheet were used as follows, all material being annealed before welding to ensure starting with material in the same condition. The rustless irons containing 12-14 per cent chromium and 14-20 per cent chromium with no nickel were annealed at 750 deg. C., a temperature commercially used. The nickel containing rustless iron was annealed at 1050 deg. C. to impart maximum ductility.

	1	*2*	*3*
Rustless iron	12-14% Cr	14-20% Cr	16-18% Cr—7-12% Ni.
Carbon	0.11%	0.08%	0.12%
Manganese	0.33%	0.29%	0.32%
Silicon	0.39%	1.05%	0.13%
Chromium	12.30%	17.21%	17.42%
Nickel			7.58%

Welds were made by the flange method using 1/16 in. wide flanges. The flanged edges were painted with a water paste of the Cromaloy

FIG. 4. DAIRY MACHINERY IS MADE FROM HIGH-CHROME ALLOYS

Flux, clamped in a jig to ensure alignment of the edges, and welded with a neutral oxy-acetylene flame. Only enough heat was used to obtain satisfactory fusion. Coupons from each type of material were tested in the "as welded" condition and after torch and furnace annealing; the temperature for furnace annealing being the same as for the sheet before welding. Bends were made transverse to the line of welding which gave an indication of the ductility of the weld and adjacent metal. On account of the thinness of the sheet and the small radius of curvature it was impossible to measure the per cent elongation in the outside fibers in the bend test. The angle of bend was therefore measured. This method does not give quantitative data, but gives information about the ductility of the welds in the various types of alloys.

The tensile properties of the sheet and welds before and after annealing were determined on coupons 1½ in. wide. A welded test piece is non-homogeneous, the weld having a higher yield point than the base metal. When such a test piece is tested in tension, the base metal adjacent to the weld is not free to elongate due to the propping or

FIG. 5. (RIGHT) TACK-WELDING A SEAM IN PASTEURIZATION TANK

FIG. 6. (BELOW) FLANGED SEAMS ARE USED IN LIGHT SHEET

FIG. 7. SEAMS SHOULD BE FLUX COATED FOR BEST JOINT

staying action of the stiffer weld metal. Consequently the per cent elongation obtained in the tensile test of a welded coupon does not necessarily express the true ductility of the weld metal or metal adjacent to the weld. When the weld has a higher yield point than the base metal, no appreciable lateral contraction takes place at the weld. The per cent elongation in 2 in. over the weld has been recorded for it indicates the relative ductility in any class in the "as welded" torch annealed or furnace annealed condition.

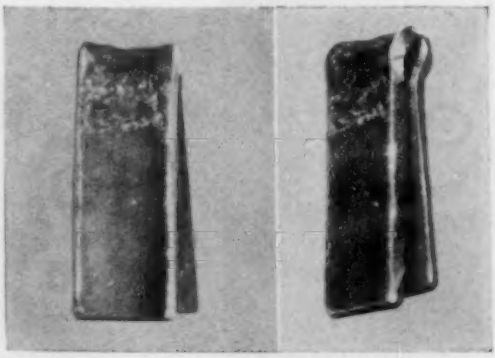


FIG. 8. SHOWING DUCTILITY OF WELDS

TENSILE TESTS. AVERAGE VALUES

No. 1. Rustless Iron. 12.30% Chromium

	Yield Point Lbs./Sq. In.	Ultimate Strength Lbs./Sq. In.	% Elongation in 2 In. Over Weld	Bend Angle
Sheet as received	53,600	78,600	34.0	180°
Sheet annealed	48,800	77,200	34.0	180°
As welded	32,400	43,700	4.0	33°
Torch annealed	55,350	76,400	6.5	85°
Furnace annealed	45,000	70,800	7.0	140°

No. 2. Rustless Iron. 17.21% Chromium

Sheet as received	63,500	77,100	31.0	180°
Sheet annealed	46,700	75,000	29.0	180°
As welded	41,500	53,400	1.0	25°
Torch annealed	47,600	68,900	6.0	110°
Furnace annealed	50,800	73,800	11.6	150°

No. 3. Rustless Iron. 17.42% Chromium, 7.58% Nickel

Sheet as received	53,500	102,100	68.0	180°
Sheet annealed	58,800	104,300	68.0	180°
As welded	54,200	66,200	15.0	150°
Torch annealed	50,400	58,000	9.0	140°
Furnace annealed	56,500	74,000	24.5	180°

Bend angles up to 35 deg. indicate brittle material; 85-110 deg. may be considered as indicating good ductility; 140-180 deg. bends indicate excellent ductility. From a consideration of the tensile results it may be seen that welds in rustless irons of either the 12-14 per cent or 14-20 per cent chromium grades are brittle and void of any appreciable

ductility, in the "as welded" condition. Considerable toughness may be imparted to the welds by torch annealing at a dull red heat for five to fifteen minutes followed by air cooling. Torch annealing of the 12-14 per cent grade gave results about on a par with furnace annealing.

Rustless irons containing 16-18 per cent chromium with about 1 per cent silicon are more easily welded than those containing less than .5

FIG. 9. WELDED STAINLESS STEEL PIPE

FIG. 10. (LEFT) WELDED PIPE FITTINGS OF HIGH-CHROME STEEL

per cent silicon and do not air-harden so readily as the 12-14 per cent chromium grade after welding. They are, however, liable to excessive grain growth at high temperatures and possibly for this reason welds and sheet adjacent to the weld in high chromium rustless irons are considerably reduced in ductility. Torch or furnace annealing at temperatures of 650-750 deg. C. will impart softness and ductility to welds in 14-20 per cent chromium rustless iron. Welds in both types of rustless iron will yield approximately the same values after annealing; viz. yield point 42,000-55,000 lb. per sq. in.; ultimate strength 65,000-75,000 lb. per sq. in.

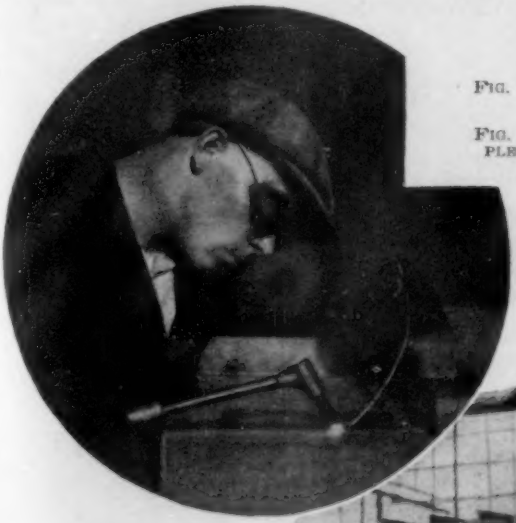


FIG. 11. (LEFT) FINISHING THE TOP SEAM.

FIG. 12. (BELOW) THE COMPLETED PASTEURIZATION TANK

Welds in rustless iron containing 16-18 per cent chromium and 7-12 per cent nickel are ductile and require no after treatment. In the "as welded" condition, welds in this alloy will have a yield point of 50,000-60,000 lb. per sq. in; ultimate strength of 65,000-75,000 lb. per sq. in. with about 15 per cent elongation in 2 in. over the weld, and may be bent through an angle of 140-180 deg., indicating very good ductility. Single vee welds in $\frac{1}{8}$-in. thick material containing 16-18 per cent

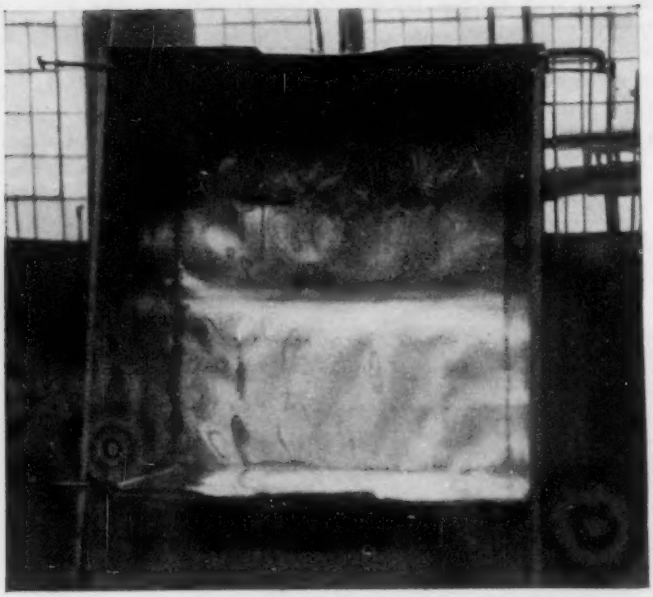


FIG. 13. INNER SEAM GROUND AND SOLDER-COATED

FIG. 14. WELDS IN HIGH NICKEL-CHROME ALLOYS DO NOT AIR-HARDEN

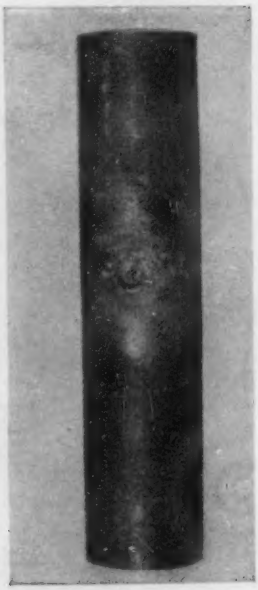


FIG. 15. BUTT-WELDED JOINT IN CHROME ALLOY PIPE

chromium and 7-12 per cent nickel have been made showing a tensile strength of 80,000 lb. per sq. in., with 32 per cent elongation in 2 in. over the weld. Since welds in this alloy show the best combination of strength and ductility in either the "as welded" condition or annealed condition, it is considered the best alloy to use for welded construction. The properties to be obtained in welds in this type alloy are dependent to a considerable degree on the quality of the metal and its physical properties before welding. For instance, moderately cold worked light gage sheet usually yields higher weld strengths than fully annealed material.

Tests have shown that the various high chromium alloys are more easily welded with the aid of a suitable flux. The use of flux cannot be emphasized too strongly, for it allows the use of a neutral flame, blankets the fusion zone preventing excess atmospheric oxidation, or carburization by the flame. Without it good fusion cannot be obtained at the bottom of the seam. Although a suitable flux will readily dissolve chromium and iron oxides, it is recommended that all surfaces to be welded be clean and free from oxide or mill scale. Before welding any particular alloy, one must consider carefully the properties of the metal, such as the effect of the welding heat, and heat treatment, if required, to produce the necessary toughness and ductility in the weld. A knowledge of the proper heat treatment for the various alloys is essential if the maximum combination of strength and ductility is desired.

CURRENT WELDING LITERATURE

All-welded Gas Holder Takes 258 Tons of Plates and Shapes. F. H. Beebe. The Iron Age (April 5, 1928), Vol. 121, No. 14, pp. 941-942. Plates are erected with narrow overlap and held with bolts at wide spacing until welder completes the seam.

Arc-Welded Steel-Frame Factory Building at the West Philadelphia Works of the General Electric Company. F. P. McKibben. General Electric Review (May, 1928), Vol. 31, No. 5, pp. 238-244. Application of welding to building construction—General problems. Description of the factory building. Details of welding in fabricating shop and field. The use of welding in structures. General description of building.

Are Welded Steel Structures. A. M. Candy. Tech. Engineering News (February, 1928), Vol. 9, pp. 15-16.

Arc Welded Structures and Bridges. A. M. Candy. American Institute of Electrical Engineers Journal (April, 1928), Vol. 47, pp. 274-277. Ten advantages given.

Arc Welding and Its Possibilities. The Popular Engineer (April, 1928), p. 13.

Bronze Filler Rods Compared. N. J. Carbis. Acetylene Journal (April, 1928), Vol. 29, No. 10, pp. 415-416. Welding may be done with several types of copper alloy rods, each kind of rod being suited to certain classes of work.

Bronze Welding Cast Iron Pipe by Backstepping Method. H. Y. Carson. Iron Trade Review (Jan. 12, 1928), pp. 138-139.

Built-Up Welding (Fusion Welding). W. Hoffmann. Ztsch. d. Ver. deut. Ing. (Feb. 18, 1928), Vol. 72, pp. 215-218.

Chrome-Molybdenum Steel in Airplane Construction. J. B. Johnson. The Iron Age (April 19, 1928), Vol. 121, No. 16, pp. 1076-1078. Successful spanning of the Atlantic from East to West by the German-Irish flyers focuses attention of the importance of alloy steels in airplane construction. The steel described in this article made up the framework of the famous Lindbergh

plane and of other planes which have made epoch-making flights in the last year.

152 Electric Welding Cuts Steel Bridge Tonnage One-Third. Electrical World (April 7, 1928), Vol. 91, No. 14, p. 707.

153 Electric Welding Development. The Australian Welding Engineer (March 1, 1928), Vol. II, No. 3, pp. 49-50. Development of laboratory process may revolutionize welding. Welds of extreme ductility and low cost produced by Electronic Tornado Process.

159 Expanding the Heating Plant. A. W. Birnie. The Welding Engineer (April, 1928), Vol. 13, No. 4, pp. 29-31. Oxy-acetylene welding is used extensively in installation of new pipe lines made necessary by numerous new buildings at Dartmouth College.

160 First All-Welded Truss Railroad Bridge Is Put in Service. Railway Age (March 24, 1928), Vol. 84, pp. 664-667.

161 Ford Shop Changes Estimated at $25,000,000. Fay Leone Faurote. The Iron Age (April 19, 1928), Vol. 121, No. 16, pp. 1080-1083. New car, which has some 5500 parts, to be produced at the rate of 6000 a day. Welding extensively employed. Half of machine tool equipment rebuilt. Unusual number of parts electrically welded. Welding equipment redesigned.

162 High-Pressure Pipe Line Fabricated by Electric Welding. Electrical World (April 21, 1928), Vol. 91, No. 16, pp. 813-814.

163 Improvement in Welding Electrodes. The Iron Age (April 9, 1928), Vol. 121, No. 16, p. 1072.

164 Industrial Progress Depends on Research. Prof. H. B. Lemon. Acetylene Journal (April, 1928), Vol. 29, No. 10, pp. 403-405. Basic information about acetylene and its application are needed not only by manufacturers but also by engineers throughout the world of industry. The nature of the atom revealed. Imagination builds a powerful research tool. The study of a frozen world. Acetylene proves a baffling subject to investigators. Knowledge of molecular systems needed in welding.

165 Leakages in Welded Vessels. The Welding Journal (March, 1928), Vol. 25, No. 294, pp. 74-75.

166 Light-Weight Combination Cutting and Welding Torch. The Iron Age (April 19, 1928), Vol. 121, No. 16, p. 1090. A new combination cutting and welding torch has been added to the line of the Alexander Milburn Co.

167 Marine Construction and Repair by Welding Processes. The Welding Journal (March, 1928), Vol. 25, No. 264, pp. 84 and 86. Tables showing test results of tensile tests on steel welds. Alternating stress tests on steel welds. Modulus of elasticity tests on steel welds. Impact tests on steel welds. Chemical analysis of electrodes and deposited metal.

168 Modern Structural Industry Demands a Knowledge of Arc Welding. C. J. Holslag. Iron and Steel Engr. (February, 1928), Vol. 5, pp. 93-95.

169 New Equipment Available. Steel Poles. Arc Welder. Electrical World (April 7, 1928), Vol. 91, No. 14, p. 741. The Truscon copper bearing "Weltrus" steel poles have been placed on the market by the Truscon Steel Co., Youngstown, Ohio.

170 New Features in the Construction of Outdoor Switch Houses. J. H. Powers. General Electric Review (April, 1928), Vol. 31, No. 4, pp. 195-196.

171 Pipe Bends Made by New Process. The Iron Age (April 5, 1928), Vol. 121, No. 14, pp. 933-934. Forcing hot pipe over horn-shaped mandrel produces short-radius bends without buckling at inside of turn or excessive thinning at outer diameter.

172 Pipe-Line Welding from the Oxy-Acetylene Viewpoint. L. R. Edwards. New England Water Works Assoc. Journal (March, 1928), Vol. 42, pp. 3-20.

173 Pipe Welding and Other Recent Developments in Welding. D. H. Deyoe. New England Water Works Assoc. Journal (March, 1928), Vol. 42, pp. 25-32.

174 Practical Studies of Electrodes. K. R. Hare. The Welding Engineer (April, 1928), Vol. 13, No. 4, pp. 43-46. Various factors which determine the suitability of a metallic electrode from the standpoint of weld quality and flowing characters.

175 Procedure for High Quality Welding. Dr. A. Krebs. Acetylene Journal (April, 1928), Vol. 29, No. 10, pp. 406-407. Some methods used in European shops to obtain high strength welds on boilers, pressure vessels and similar

structures. Regulations in European countries. Need for definite procedures. Vertical welds in double beveled plates. Advantages of this method.

Qualifications for Welders. The Iron Age (May 3, 1928), Vol. 121, No. 18, pp. 1244 and 1293. American Welding Society in Annual Meeting holds symposium on acceptance tests for workmen. Standardization for code purposes to follow detailed study.

Railroad Bridge Made by Arc Welding. A. G. Bissell. The Iron Age (April 12, 1928), Vol. 121, No. 15, p. 1013.

Reclaiming a Cast-Iron Waterwheel Casing. C. W. Babcock. Boston Soc. Civil Engrs. (February, 1928), Vol. 15, pp. 88-92.

Researches on Commercial Carbide of Calcium. The Welding Journal (March, 1928), Vol. 25, No. 294, pp. 76-77. Calcium carbide samples. Visual inspection.

Resistance Welding Aids Redesign. The Welding Engineer (April, 1928), Vol. 13, No. 4, pp. 37-39. Examples of spot and flash welding in the Ford Motor Co. plant show how these processes make possible an entirely new kind of automobile.

The Manufacturing of Carbide of Calcium. Charles Bingham, C. E., and C. H. Bingham, Jr. 225 page book published by the Welding Journal, 30, Red Lion Square, London, W. C. 1. The contents of this book are: Historical. Chemistry. Choice of Site. Design and Equipment. Electric Furnaces. Construction of Furnaces. The Bottom Electrode. The Upper Electrode. Screeners for Carbide. Transport Appliances. Laboratory. Limekilns. Materials of Manufacture. Results of Manufacture. Working Results and Powerplant. Heat and the Losses in Furnace. Electrode Consumption. Power Factors. Testing of Carbide and Quality. Overheating in Acetylene Generators.

Thousand-Ton Structure Welded. The Iron Age (March 22, 1928), Vol. 12, pp. 804-805.

Throwing a Smokestack. Acetylene Journal (April, 1928), Vol. 29, No. 10, pp. 408-411. So small and light a tool as the oxy-acetylene cutting torch accurately controls the fall of a huge stack weighing many tons.

Use of Electric Welding in Structural Work. Commonwealth Engineer (Jan. 2, 1928), Vol. 15, pp. 223-224. Petrol tanks and a wagon shop at Maribyrnong, Victoria, made by electric welding.

Wanted—A Steel Welding. Hyman Levine. The Welding Engineer (April, 1928), Vol. 13, No. 4, pp. 32-33. A plant to manufacture welded steel parts on a commercial scale is one of the big needs of the welding industry today.

Water Pipe, Five Tons per Section, Fabricated in California. The Iron Age (April 26, 1928), Vol. 121, No. 17, pp. 1156-1157.

Welded Bridge at Chicopee Falls. G. D. Fish. Engng. & Contr. (March, 1928), Vol. 67, pp. 163-164.

Welded Joints Save Pilot's Life. The Welding Engineer (April, 1928), Vol. 13, No. 4, p. 49.

Welding Aids Mining Engineers. Acetylene Journal (April, 1928), Vol. 29, No. 10, pp. 412-414. The oxy-acetylene process is constantly at work on construction and repair of equipment.

Welding Chrome Irons and Steels. The Iron Age (May 3, 1928), Vol. 12, No. 18, pp. 1242-1244. Must prepare a clean joint, use a proper flux and a strictly neutral flame of minimum dimensions, ending with a properly adjusted heat treatment. Heat treatment of welded joints. Castings should be welded hot. Rustless chrome-nickel irons give ductile welds.

Welding Facts and Figures—23. D. Richardson and E. W. Birch. The Welding Journal (March, 1928), Vol. 25, No. 294, pp. 70-73. Handbook for welding engineers.

Welding Mexico. J. B. Green. The Welding Engineer (April, 1928), Vol. 13, No. 4, pp. 46-47. A report of present conditions indication that the U. S. must export welding talent before it can sell welding equipment.

Welding—Methods and Uses. Contrs. & Engrs. Monthly (March, 1928), Vol. 16, pp. 164-169. A symposium of data contributed by manufacturers and users, on the use of electric arc, fusion, resistance, spot thermit, percussive welding.

Wholly Inclosed Arc Welder. The Iron Age (April 5, 1928), Vol. 121, No. 14, p. 948. A new 200-amp. single-operator welding set has been designed by the Westinghouse Electric & Manufacturing Company.

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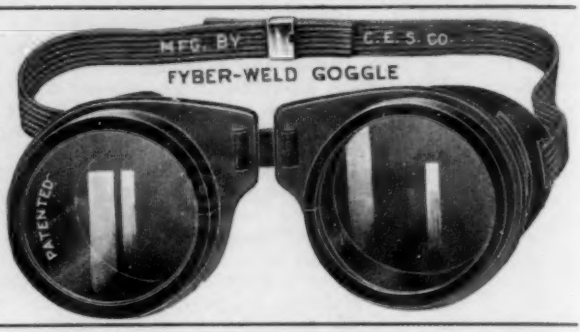

Instruction Manuals

The Educational Committee of the American Welding Society has issued instruction manuals for Arc, Gas, Resistance and Thermit Welding. A few copies of the bound volume of these manuals are still available at $2.50 per copy. Individual courses may be obtained at 50c. per copy. (Resistance course 35c.)

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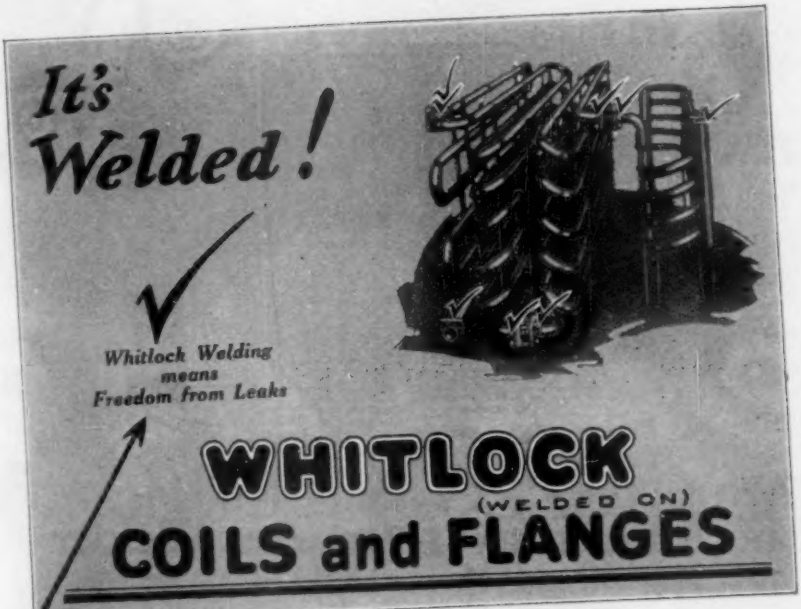

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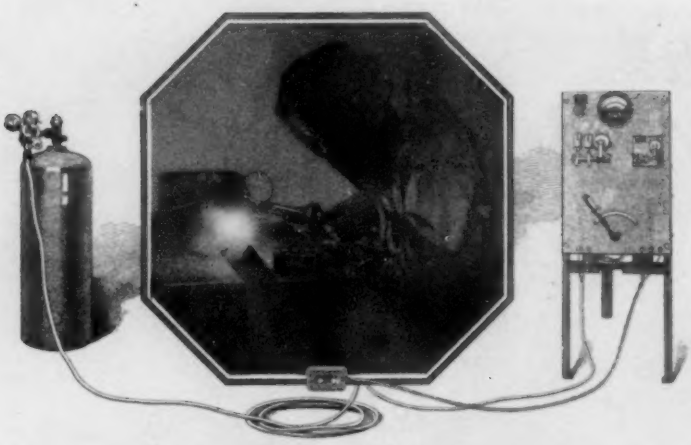

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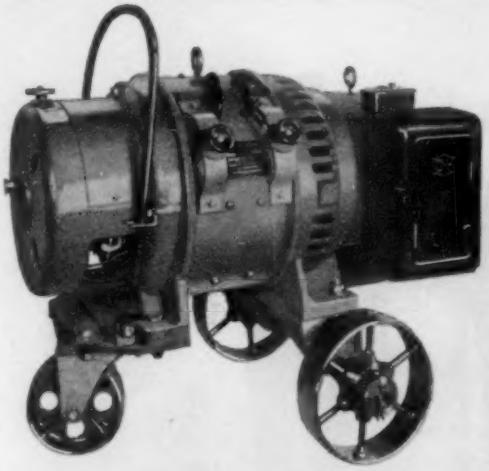

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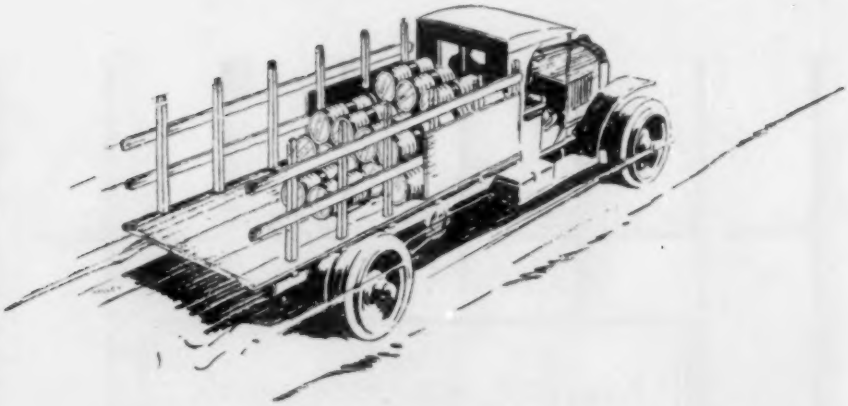

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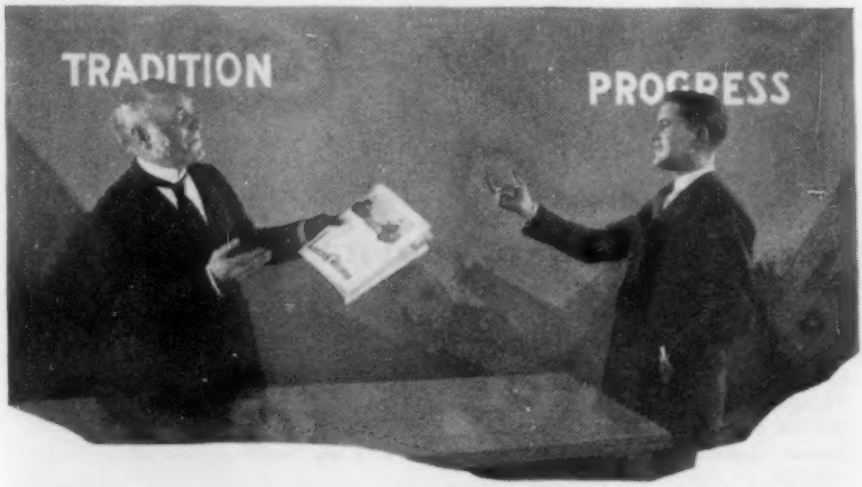

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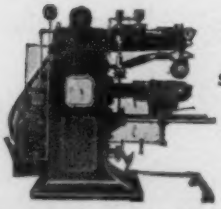
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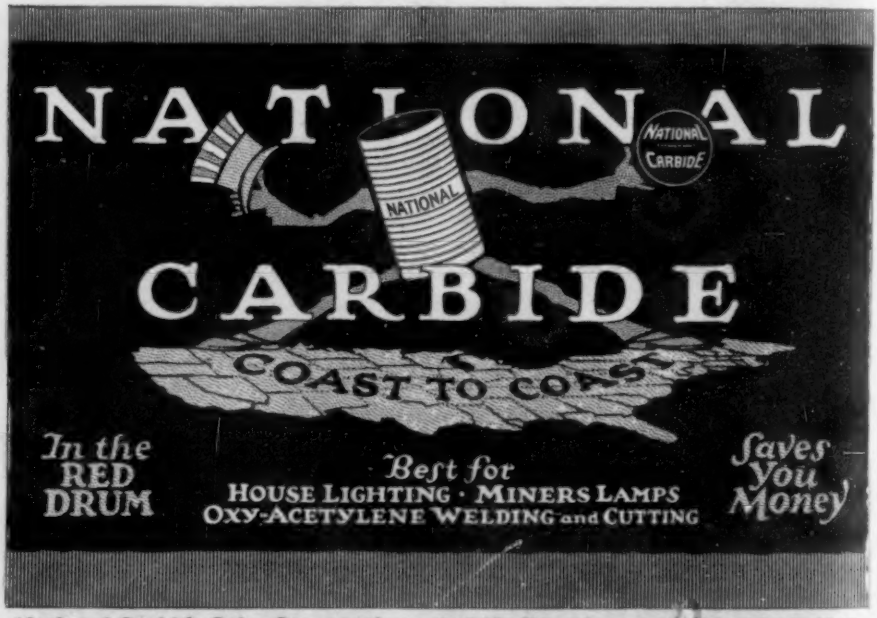

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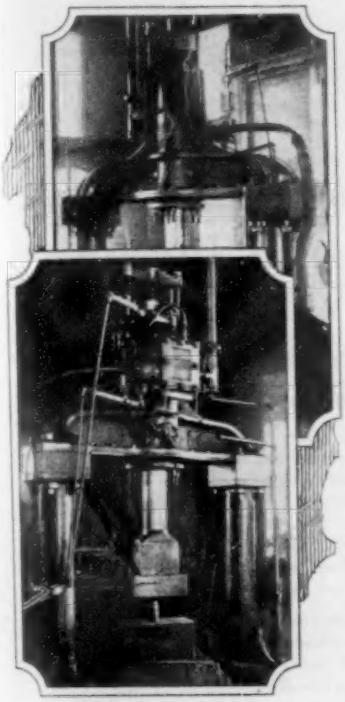

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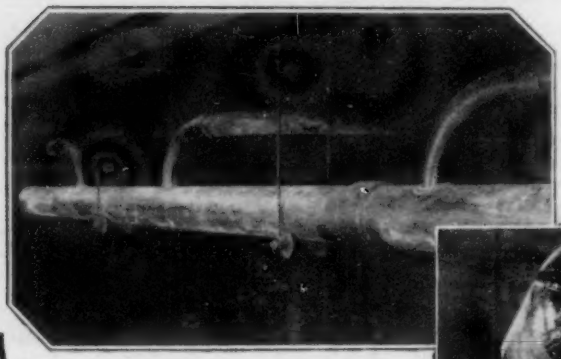
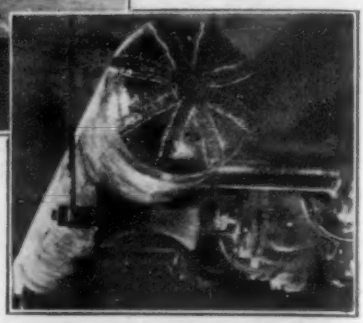


At left: The 10-inch main steam header, showing welded collar joints. Below: One of the arc-welded bull-nosed ends.



STEAM PIPING *in the* St. Luke's Hospital of Cleveland *electrically welded with* WILSON WIRE

IN building the St. Luke's Hospital, Cleveland, practically all the connections in the steam piping system were electric welded—and in all this electric welding work Wilson was used ***exclusively.***

The left-hand illustration above shows the method of joining lengths in the 10-inch main steam header. A small sealing weld was made at the scarfed ends, and then built up into a flush weld. Around the outside of this weld a steel collar was placed and welded to each pipe for mechanical strength. The joints in the curved pipes leading from the main steam header were made in the same way, and all flanges welded to the pipes.

The right-hand illustration shows how the bull-nosed ends were built up to terminate the high pressure headers—an excellent example of the ***strength*** secured by ***electric welding.***

What Wilson "Color-tipt" Wire has proven to others it can prove to ***you,*** and in so doing will solve your welding problem. Whatever the industry, there is the ***right*** grade (analysis) of Wilson Wire for the particular metal ***you*** are welding—and every grade runs ***uniform throughout.***

And wherever the industry there is a Wilson Model S Welding Machine that will meet ***your*** particular welding requirements and operating conditions—a one-arc gasoline-engine-driven, belt-driven or motor-driven unit, or a two-arc motor-driven unit, with capacities of 10-250, 10-300, 10-600, 15-500, 15-1000 amperes.

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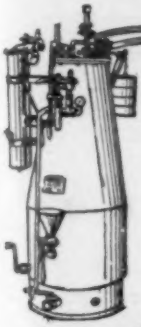

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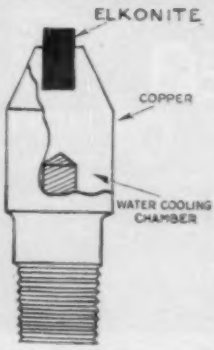

FIG. 1 WATER COOLED SPOT WELDING ELECTRODE SHOWING ELKONITE INSERT. COURTESY GENERAL ELECTRIC CO.

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This is but one phase of the contribution that Elkonite has made to resistance welding. In flash, cross-wire, projection welding, electrical upsetting of rivets, as well as in spot welding non-ferrous and heavy gauge ferrous metals Elkonite, by eliminating lost time and production due to constant redressing, and shrinkage loss, is showing new economies and production possibilities in many industries.

Our engineering staff will gladly co-operate in any resistance welding problem.

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NEW YORK, N. Y.

.....192..

Secretary:

I hereby apply for Membership in the AMERICAN WELDING SOCIETY as a ..... Member and attach
(Note Grades on other side)
hereto remittance of $..... for first annual dues. Remittance will be refunded in the event of rejection of applicant. I also agree to abide by the Constitution and By-Laws of the Society.

Name .....

Present occupation .....

Name of Company and Address .....

Residence .....

Address for mailing .....

Applicant is requested to state here length of welding experience and processes involved, also to record any technical or mechanical experience or special interest in the welding field.

.....

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.....

.....

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References: (1. .....

(at least two) (2. .....

Proposed by .....

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QUALIFICATIONS FOR MEMBERSHIP

Extract from By-Laws

ARTICLE I.

Section 1. Individuals having received the approval of a majority of the Membership Committee shall become members of this Society upon the payment of dues, except in the cases of honorary members who shall be elected by unanimous vote of the full Board of Directors.

Section 2. Membership shall be divided into five classes:

Sustaining members, being individuals or individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership.

Annual dues..... ..... $100.00

Members, being individuals interested in the science and art of welding, with full rights of membership. Engineers or individuals competent by experience or training to plan or direct welding operations are eligible to this class.

Annual dues..... $20.00

Associate members with right to vote but not to hold office, except in Sections as may be provided for by the By-Laws of the Section. Supervising welders, inspectors and skilled operators, with three or more years' practical experience in welding, are also eligible to this class.

Annual dues..... $10.00

Operating members, who are welders or cutters by occupation, without the right to vote or hold office except in Sections as may be provided for by the By-Laws of the Sections.

Annual dues, United States and Canada $5.00
Other countries..... $10.00

Student Members, who are actually in attendance at any one of the recognized colleges and approved trade schools, without the right to vote or to hold office except in sections as may be provided for by the By-Laws of the Section.

Annual dues..... $2.50

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